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GUIDELINES FOR AIR QUALITY MAINTENANCE PLANNING AND ANALYSIS. VOLUME 3. CONTROL STRATEGIES

Environmental Protection Agency

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16. ABSTRACT

This report describes 18 different measures that have been used or proposed for use in maintaining air quality standards in regional areas. For each measure, information has been assembled on current applications (case histories), recommendations for implementing the measure, estimates of potential effectiveness, and conditions under which the measure is most applicable. Many of the measures reviewed are based on land-use or regional planning, and are concerned primarily with new sources of emissions. These include: emission allocation procedures, regional development planning, emission density zoning, zoning approvals, transportation controls, emission charges, transfer of emission source location, indirect source review, and environmental impact statements. Other measures are technological in nature: new source performance standards, more stringent control of existing sources, phaseout or prohibition of emission sources, fuel conversion, energy conservation and utilization, combination of emission sources, special operating conditions, stack height regulations, and control of fugitive dust sources

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GUIDELINES FOR AIR QUALITY MAINTENANCE PLANNING AND ANALYSIS

VOLUME 3:

CONTROL STRATEGIES

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, N. C. 27711

July 1974

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FOREWORD

This document is the third in a series comprising Guidelines for Air Quality Maintenance Planning and Analysis. The intent of the series is to provide State and local agencies with information and guidance for the preparation of Air Quality Maintenance Plans required under 40 CFR 51. The volumes in this series are:

Volume 1: Designation of Air Quality Maintenance Areas
Volume 2: Plan Preparation
Volume 3: Control Strategies
Volume 4: Land Use and Transportation Considerations
Volume 5: Case Studies in Plan Development
Volume 6: Overview of Air Quality Maintenance Area Analysis
Volume 7: Projecting County Emissions
Volume 8: Computer-Assisted Area Source Emissions Gridding Procedure
Volume 9: Evaluating Indirect Sources
Volume 10: Reviewing New Stationary Sources
Volume 11: Air Quality Monitoring and Data Analysis
Volume 12: Applying Atmospheric Simulation Models to Air Quality Maintenance Areas

Additional volumes may be issued.

All references to 40 CFR Part 51 in this document are to the regulations as amended through July 1974.

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Chapter I: INTRODUCTION

A. GENERAL

The purpose of this report is to describe several alternate administrative and technical programs for the maintenance of air quality standards in designated Air Quality Maintenance Areas (AQMA's). Individual programs that act to maintain air quality standards, either through the prevention or reduction of emissions or the spatial and temporal redistribution of emissions, are termed maintenance measures. The maintenance measures described herein are shown in table I-1. Groups of one or more compatible maintenance measures that are expected to provide the total necessary control of emissions in an AQMA are referred to in this report as maintenance strategies.

Volume 2 of this quideline series, Plan Preparation, recommends that a two-stage procedure be used in selecting the preferred group of maintenance measures for an AQMA: screening of all potential measures for those that are feasible and compatible, followed by selection based on socioeconomic evaluations. It is anticipated that the information in this report will be useful primarily for the initial stage, in identifying and screening measures for applicability in a particular AQMA.

The description of each of the 18 measures covered is organized into the following topics:

- A brief definition of the measure
- Current applications (case histories)
- Recommendations for implementing the measure
- Conditions of applicability, interactions with other measures, potential conflicts with other community development plans, and practical limitations
- Estimates of potential effectiveness

Some of the measures have not been used previously by control agencies or planners to improve air quality. Only limited experience

Table I-1. Air quality maintenance measures

LAND USE AND PLANNING MEASURES

- Emission Allocation Procedures
- Regional Development Planning
- Emission Density Zoning
- Zoning Approvals and Other Indirect Regulatory Controls
- Transportation Controls
- Emission Charges
- Transfer of Emission Source Location
- Indirect Source Review
- Environmental Impact Statements

EMISSION CONTROL MEASURES

- New Source Performance Standards
- Revision of Existing SIP Control Measures
- Phaseout or Prohibition of Emission Sources
- Fuel Conversion
- Energy Conservation and Utilization
- Combination of Emission Sources
- Special Operating Conditions
- Stack Height Regulations
- Control of Fugitive Dust Sources

in the application of other measures is available. In contrast, applications of some measures have been so varied that an entire document could be written on each one. Therefore, with the exception of the case history data, the information presented is necessarily general. Analyses and conclusions drawn from the case histories usually have not been stated directly. However, these conclusions have formed part of the basis for recommendations on implementation of the measure and are also a factor in the estimates of potential effectiveness.

The report discusses three measures that are already in effect in all AQMA's regardless of maintenance plan provisions--indirect source review, Environmental Impact Statements (EIS's), and Federal New Source Performance Standards (NSPS). It is important that the capabilities of these measures for maintenance be known and considered in the preparation of Air Quality Maintenance Plans (AQMP's).

Three other tools available under the Clean Air Act that may serve to mitigate the impact of general growth are discussed within other sections--the requirement in 40 CFR 51.18 that each State Implementation Plan (SIP) have procedures to review, and if necessary prevent, the construction or modification of stationary sources at any location that would result in interference with the attainment or maintenance of a national standard; emission standards for new motor vehicles promulgated under section 202 of the Act; and requirements in section 110, that the Administrator call for revision of inadequate SIP's whenever ambient air quality monitoring or other information indicates the necessity.

B. TYPES OF MAINTENANCE MEASURES AVAILABLE

In theory, air quality maintenance measures are to be implemented to keep air quality better than or equal to the National Air Quality Ambient Standards (NAAQS). Ideally, the measures would affect primarily the growth component of AQMA emissions, both from new sources and from increases in activity levels at existing sources, by controlling the amount, timing, and/or location of new emissions. Based on this concept, maintenance measures could also be characterized as moderate, long-term actions that are capable of offsetting the growth in regional emissions that would occur without some comprehensive plan, and that act to reduce emissions at about the same rate at which the new emissions begin. Therefore, preferred measures should emphasize management and preventive aspects of air pollution control. However, if pollutant concentrations are at or above the NAAQS at the time the AQMP is to be implemented, measures that provide for additional emission reductions by existing sources must be included in the maintenance strategy (or a separate attainment plan must be submitted).

Unlike provisions in the control strategies of the SIP's, maintenance measures must be implemented prior to the time that excessive emissions would otherwise occur. Because of this prior implementation, they are particularly sensitive to planning projections used in the development of maintenance plans. NAAQS may never be exceeded in one part of an AQMA just because projected growth or emission sources do not materialize. On the other hand, maintenance measures may fail in their objective even though they are properly implemented, due to incorrect estimates of the rate, location, or amount of projected growth, or to the impact of projected additional emissions on air quality.

Identification of specific measures that have the characteristics described above is a difficult task. The 18 measures presented are thought to include the major approaches to air quality maintenance. However, the example types of applications discussed under each measure may include only a few of the many possible applications. Those involved in the development of a maintenance strategy are encouraged to seek additional measures or applications that may be specific to the AQMA.

These measures have been divided into two classes--land-use and planning measures and emission control measures--based on some distinguishing characteristics that were observed among different measures. Since this classification is somewhat arbitrary, a few of the measures have characteristics of both of the classes.

Land-use and planning measures, as the name implies, are primarily involved with planning for future regional air quality. They are concerned mainly with new emission sources. As such, they usually have an indirect or inactive effect on emissions from any specific source. Important land-use and planning measures are discussed in chapter II.

In contrast, emission control measures are technological or operational changes that most often affect existing sources (NSPS are a notable exception). The result is a reduced quantity of emissions, a reduced impact of emissions on ground-level air quality, or a temporal redistribution of emissions. Emissions control measures tend to have a direct, active effect on emissions from individual sources and, hence, their impact can be quantified much better than that of land-use and planning measures. Emission control measures are discussed in chapter III.

No order of priority or hierarchy of these measures appears appropriate, except that an SIP revision (more stringent controls on existing sources) is to be considered prior to the evaluation of maintenance measures. The observation is made that most of the land-use and planning measures (except indirect source review and EIS's) represent comprehensive approaches to air quality maintenance, while the emission control measures generally apply only to specific source categories. Therefore, the emission control measures may be implemented within the framework of different land-use and planning measures, and may be the specific actions taken to effect emission reductions that are needed under a land-use and planning measure. However, individual or groups of emission control measures can also provide for maintenance independently of any land-use and planning measure.

Chapter II: LAND USE AND PLANNING MEASURES

A. EMISSION ALLOCATION PROCEDURES

1. Definition of the Measure

Emission allocation is a maintenance measure that requires emissions of pollutants be limited to prescribed levels within an airshed, air basin, AQMA, or portion thereof. On the regional level, a relationship is established between the assimilative capacity of the ambient air in the region and the amount of emissions within the region that would not violate air quality standards. The emission allocation procedure would probably be administered by an agency or several agencies having cognizance over air pollution or land use. A special entity having representation of air pollution agencies and land-use planning and control agencies and created for administering emission allocation procedures is also a viable alternative.

The procedure may be applied to all pollutants and to both existing and new point, line, and area sources. Although related to emission density zoning, emission allocation should be viewed as a much more generalized technique concerned with regional air pollution problems that focuses on the comprehensive land-use plan as the basic document from which future levels of air quality are estimated. In contrast, while applicable to all land uses, emission density zoning is a more specific technique most applicable to controlling stationary source pollutants in localities having heavy concentrations of industry.

The purpose of emission allocation is to utilize land-use-based measures to control the air pollution potential of comprehensive land-use plans within an AQMA or some other defined region. The land-use plans, therefore, need to be viewed as an accurate representation of the future development that can be expected in the region. The land-use plans, associated transportation plans, and the emission factors thus assume key positions in estimating future levels of air quality.

2. Historical Review of the Measure

a. Current Application of the Measure. Emission allocation procedures are not currently being utilized by any air pollution control or land-use planning agency in the United States. There are no current zoning or planning regulations containing emission limits based on a regional definition of assimilative capacity. There is a bill in the California Assembly (S.B. 1543), however, that would mandate the application of this procedure in the 11 air basins in the State of California.

The concept of emission allocation procedures is that there should be established some relationship between total air pollutant emissions in a region and the assimilative capacity of the ambient air in the region, and that this relationship can be projected into the future to establish the total amount of emissions that can be allowed at some future point in time. A principal assumption is made that there is a direct relationship between urban growth and increasing levels of air pollution. Thus, if future areas and levels of land development in a region can be predicted, the type of air quality maintenance strategy that would be necessary to ensure that air quality standards will not be violated could be determined. The comprehensive land-use plan provides this prediction of future development.

The recognition of the importance of land-use planning as a technique for air quality improvement led the California legislature in 1972 to direct the California Air Resources Board (ARB) to prepare a report on proposed guidelines for the preparation of an air pollution control element in city and county general plans. In response to this mandate, the ARB let a contract to the consulting firm of Livingston and Blayney to prepare such a report in cooperation with the ARB staff. However, as the study progressed in early 1973, it became apparent that air quality management could be effectively integrated with land-use and transportation planning only on an air-basin-wide scale. Accordingly, the procedures that the consultant recommended would vest responsibility in regional agencies for allocating air pollutant emissions limits within each air basin of the State.

However, for States maintaining centralized control over air pollution control activities, responsibility could be vested in the State agency and the program administered from that level in cooperation with local and regional agencies.

b. Effectiveness of the Measure in Current Applications. Since the emission allocation procedures have not been applied to date in the State of California, it is impossible at this time to determine the effectiveness of the measure. The potential effectiveness of the measure is discussed later in this section.

3. Implementation

a. Procedure. Emissions allocation could be established and implemented in several different ways, depending on the types and levels of government involved. One generalized procedure is described here; it is emphasized that the agencies recommended for participation are just for this example procedure.

Six steps are proposed to integrate air quality goals into the land-use and transportation planning process under the emission allocation procedures.

1) Compile detailed inventories of air pollution emissions in planning subareas of an AQMA or air basin. Emission data must be obtained for each planning subarea and not disaggregated from county or AQMA totals.

2) Designate maximum emissions allowable in each planning subarea to achieve and maintain air quality standards, based on an analysis of present air quality and the assimilative capacity of the air to absorb pollutants and still maintain air quality standards.

3) Estimate planning subarea emissions likely to be generated by sources indicated in land-use and transportation plans for designated future time periods and compare these emissions with the allowable emission limits.

4) Evaluate and revise land-use and transportation plans so that prescribed emissions limits would not be exceeded.

5) Adopt and implement land-use and transportation plans, emission controls, and other measures that are prepared to meet air quality goals and standards.

6) Monitor public and private development through a refined environmental impact assessment process in which emissions projected directly or indirectly from proposed projects are accounted for in EIS's.

The key to this process is the concept of allocating air pollutant emissions within an AQMA. As long as plans and projects conform to prescribed emission limits, air quality standards should be maintained. An appeal process would permit deviation from prescribed limits where technical information is available to demonstrate that air quality standards will not be exceeded by the proposed deviation.

The responsible agency in the AQMA would compile the planning subareas' emissions inventories and then designate the emissions limits for each planning subarea. Planning agencies would make emissions projections based on their plans to meet prescribed emission limits. Transportation planning agencies likewise would make projections of the emissions that would be generated by their proposed plans and would revise them accordingly. A significant amount of interaction between the agencies involved would be necessary before all plans throughout an AQMA or air basin met the prescribed emissions limits. If and when the allowable limit is reached, some equitable procedure must be developed to permit additional growth and development. Hopefully, this will not occur until later, in or after the 1975-1985 period covered by the AQMP. By that time improved control technology and experience gained during the implementation of the AQMP should permit revision of the plan to accommodate additional growth while maintaining NAAQS.

Appeals to exceed emissions limits would be decided by the State or designated regional agency, if such responsibility has been so designated. Once the plans have been approved by this agency, the responsibility for implementing them would probably rest at the level of cities and counties. However, the designated regional agency would continue to monitor development to ensure that emission limits would not be violated. The State agency would retain the overall responsibility for monitoring the program and intervening where necessary to ensure compliance with established procedures and criteria.

While the emission allocation process has been designed to utilize existing land-use and transportation plans, air quality standards, and emission inventories, the procedures can also utilize new land-use and transportation plans developed specifically with air quality objectives in mind. In such a case the AQMP could consist of a program to develop a comprehensive plan plus a series of emission reduction measures for the initial portion of the 10-year period. Upon completion of the comprehensive land-use plan, the State would develop an appropriate long-range AQMP incorporating emission allocation procedures. The State, in the submission of the AQMP, must demonstrate the capability to develop a mechanism for the creation of a comprehensive plan that recognizes the requirement for the maintenance of air quality.

The first step is to compile an emissions inventory for areas within the air basin for a base year. Planning subareas would best be chosen to conform as much as possible to the boundaries of political subdivisions, census tracts, and existing planning areas. They also would have to be of small enough size to permit definition of specific areas with air quality maintenance problems.

Given the emissions inventory and air quality data obtained by monitoring in the planning subarea and the air basin for the base year, the maximum allowable emissions that should meet air quality standards in each subarea can be set. Two possible options for the designation of maximum emissions allowable in a planning subarea can be considered. Either the dispersion or proportional model can be used to estimate the control requirements in each planning subarea. The dispersion model is preferred if sufficient data are available for its validation. Furthermore, proposed regulations for supplementary control systems indicate that EPA is going to require dispersion models to evaluate particulate and SO_X strategies unless it can be demonstrated that such models are not appropriate.

To designate the maximum allowable emissions for other than photochemically reactive pollutants in each planning subarea, the relationship for each pollutant category E_m in the planning subarea to the allowable emissions in an air basin according to the implementation plan would be the same relationship obtaining for the emissions in a planning subarea base year to the emissions in an air basin base year. This allocation can be expressed as follows:

$$\frac{E_m \text{ allowable in planning subarea}}{E_m \text{ allowable in air basin according to implementation plan}} = \frac{E_m \text{ planning subarea base year}}{E_m \text{ air basin base year}}$$

where E_m refers to emissions for each pollutant category.

In a planning subarea, 80 tons of sulfur dioxide per day might be emitted in 1970, and the basinwide proportional growth that could still maintain the air quality standard for sulfur dioxide might be 25 percent. In this case, the emissions of sulfur dioxide allowable in the subarea would be 100 tons of SO_2 per day.

If a dispersion model is validated and accepted by the air pollution control and land-use planning agencies, the air basin emissions allocations for pollutants may conform to the model's projection for achieving and maintaining air quality standards. With such a model, it is anticipated that it would not be necessary to reduce emissions in all planning subareas in the basin as drastically as required in the subarea with the worst air in order to meet air quality standards, because the transport of pollutants from one subarea to another could be simulated.

Implementation of emission allocation procedures requires a coordinated effort at all levels of government, State to local. The specific requirements of emission allocation procedures must be considered in the development of the management and organizational structure required for implementation of the AQMP. The exact structure will be dictated by local requirements.

Because land-use, transportation, and emission control plans are regional in nature, there may be merit in the State's retaining responsibility for their preparation and promulgation. Such an approach would minimize the problems that can result from locally developed plans designed to attain diverse and sometimes competing goals. In any event, the State must retain ultimate responsibility for ensuring that regional and local plans are compatible and promulgate State-developed plans if necessary to resolve local level conflicts.

A description of the proposed operation of emission allocation procedures in the State of California provides insights into the functions and organizational structure that may be used for implementation of this measure. It must be borne in mind that, in California, land-use, transportation, and air quality planning responsibilities are decentralized using the nesting approach whereby the State prescribes general requirements with successively more specific requirements being developed at lower levels. While the specific organizational and responsibility structure may not be completely applicable for other States, the functions being carried out at the regional and local levels must be performed by some agency, whether or not responsibilities are delegated to activities below the State level.

The following agencies are involved in the California plan for operationalizing emission allocation procedures:

Air Resources Board (ARB). The State air pollution control agency.

Basin-wide Air Pollution Control Coordinating Councils (BCC). Regional agencies responsible for preparing and implementing basin-wide air pollution control plans. BCC's are composed of groups of county air pollution control districts.

Local Agency Formation Commission (LAFCO). A commission that usually operates at the county level charged with the responsibility of determining maximum service areas and service capacities.

City and county governments.

Air Pollution Control Districts. A county or multicounty agency.

Regional Transportation Planning Agencies.

Governor's Office of Planning and Research.

The duties to be carried out by these organizations are as follows:

1) The Air Resources Board shall:

- Establish emission limits for each pollutant for each basin by July 1975.
- Provide emission factors that relate quantity and type of pollutants to land-use and transportation plans.
- Review and approve methodology utilized by air-basin-wide agencies in allocating emissions limits to planning subareas.
- Provide technical support to other agencies.

Upon passage of legislation, the program shall be activated in the Sacramento, San Joaquin, San Francisco, San Diego, and South Coast Air Basins. The ARB shall monitor general plans in the other air basins of the State. At its discretion, it may activate the program in other basins or portions of other basins of the State where it determines that achievement and maintenance of air quality goals may be endangered by projected growth and development.

2) The Basin-wide Air Pollution Control Coordinating Councils (the designated regional agencies in this case) shall:

- Subdivide the air basin for the purpose of establishing emissions limits.

- Adopt emissions limits stating the quantity of pollutants in each pollutant category that can be emitted in the air in each subdivision of the air basin by December 31, 1975. The totals for all areas shall not exceed ARB limits established for the air basin.
- Review the emissions limits periodically and adopt amendments when new data indicate that a different quantity of pollutants should be allocated.
- Require a current, detailed emissions inventory and periodic updating.
- Provide technical assistance to cities, counties, Councils of Government, and regional transportation planning agencies on the preparation of general plans and transportation plans that would conform to emissions limits, and on the utilization of emissions allocations and emissions limits in evaluating the air quality impact of proposed projects in environmental impact reports.
- Define projects likely to have a significant impact on air quality.
- Review environmental impact reports prepared for projects with potentially significant air quality impacts and for major growth-inducing projects.
- Review within 90 days of receipt, city and county general plans, regional land-use plans, and regional transportation plans in accord with procedures and methodology prescribed by the Air Resources Board, and approve plans that are judged to maintain projected emissions from planned land uses and transportation facilities within emissions limits allocated to the basin subdivisions.
- Establish procedures for BCC review of applications to the LAFCO* to annex or incorporate territory, or to create special districts or expand their service areas or functions, for potential impact on air quality, and notify each local agency formation commission of any expected violations of air quality goals likely to result directly or indirectly from application approval.

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*LAFCO's are required by Assembly Bill 237 (1972) to undertake studies of existing governmental agencies, including dependent special districts, in order to determine maximum service areas and service capacities. They usually operate at the county level.

3) Cities and counties shall:

- Determine that projected air pollution emissions, directly or indirectly generated by land uses designated in the land-use element and by transportation facilities designated in the circulation element, do not exceed the allowable emissions allocated to the city or county and air basin subdivision by the BCC or equivalent agency.
- Submit the general plan to the BCC for review for consistency with air pollution emissions limits by December 31, 1976.
- After the receipt of the allocation of emissions limits prescribed by the BCC, submit to the BCC for review the adopted general plan and a projection of the quantity of emissions in each pollutant category resulting from the plan's proposals.
- After receiving a notice of disapproval of the plan for failure to meet emissions limits, submit a revised plan and projection of emissions to the BCC for review.
- Modify the objectives, criteria, and procedures adopted for evaluation of projects and preparation of environmental impact reports to include procedures for the projection of air pollutant emissions, directly or indirectly generated by proposed projects, and for the evaluation of emissions with reference to emissions limits allocated to air basin subdivisions within the jurisdiction of the city or county by the BCC.

4) Local Agency Formation Commissions (LAFCO) shall:

- Prior to the approval of an application for annexation, incorporation or the creation of a special district, or the expansion of a special district's territory or functions, consider the effect of the proposed action on air quality and on the emissions limits allocated by the BCC to the air basin subdivision affected by the application.
- Require that the project conform with the emissions limits assigned to the air basin subdivision in which the project would be located, as well as with city or county general and specific plans.

5) Air Pollution Control Districts shall:

- Revise their orders, rules, and regulations to be consistent with the allocation of emissions limits prescribed by the BCC, particularly those regulations regarding complex sources aimed at preventing the construction or operation of facilities that either directly or indirectly would cause emissions allocations to be exceeded.

- Require the developer of any project of the type defined as major growth inducing or likely to have a significant impact on air quality by the BCC to obtain a permit from the air pollution control district.
- Issue no permit for the construction, alteration, or operation of any project for which projected emissions would exceed the limits allocated to the air basin subdivision or city or county.

6) Regional Transportation Planning Agencies shall:

- Determine that the regional plan is consistent with the allocation of emissions limits prescribed for the air basin.
- Provide a report of projected emissions from the transportation system proposed in the plan in the EIS now required.
- Not adopt a regional transportation plan until receipt of a statement of approval from the BCC, certifying that the emissions projected from the proposed transportation system do not exceed the limits allocated to the air basin or its subdivisions.

7) Office of Planning and Research shall:

- Prepare in conjunction with the ARB and the Council on Intergovernmental Relations a handbook of technical guidelines and administrative procedures for reviewing and projecting emissions from proposed projects, for reducing emissions in existing and proposed developments, and for preparing plans that maintain emissions within allocations of emissions limits.

b. Conditions of Applicability. Following the earlier discussion, prerequisite conditions of applicability are as follows:

1) The availability of a current emissions inventory and land-use data. This land-use data would be for current land use and for expected future development.

2) The availability of sufficient resources to develop the emissions rates and to administer the regulations over time.

3) The availability of sufficient monitoring data either to calculate the emissions ceiling of the proportional model or to calibrate the dispersion model.

4) A well-developed land-use and transportation planning capability on the part of municipal and county or regional government.

5) Appropriate enabling legislation.

If all these data and capabilities are present or can be assembled, an emissions allocation procedure can be used for any combination of emissions sources, and within a wide range of administrative structures. This measure offers a broad, flexible approach that is directed specifically at maintenance of air quality standards, and would be applicable in most AQMA's. The primary limitations on the use of emissions allocation result from its large, continuing administrative staffing requirements and its need for extensive interagency cooperation.

c. Interactions with Other Measures. In general, emission allocation procedures may be thought of as a framework within which other measures can be applied. This measure does not provide the actual emission reductions and is therefore dependent on the existence of other measures to provide reductions shown to be needed in particular subareas. However, it does provide control over the admittance of new sources into subareas that are either approaching or are at their emissions allocation.

The procedures would be a supplement to source control regulations and could be administered in concert with them. Used together, they would be particularly valuable in avoiding "hot spots," areas where large sources cluster and technological source controls are not adequate to avoid local violations of air quality standards.

Emissions allocation procedures can also provide an overall structure in which other administrative measures, such as emission density zoning, indirect source review, or transportation control plans, can function. The interaction with emission density zoning is discussed in the section on that measure. In California, the proposed maintenance plan utilizes both indirect source regulation and State-required environmental impact assessments as integral parts of their emissions allocations procedure.

d. Potential Conflicts and Negative Impacts. California's experience in conceptualizing the procedures and organization to operationalize emission allocation procedures indicates some potential problem areas that must be considered in the development of similar procedures by other States. The major difficulty with the program as initially conceived was that it would mean that no growth or development would be allowed in the Los Angeles air basin over the short-term, at least until the automobile becomes a much cleaner means of transportation or major reductions in existing stationary sources are obtainable. The Air Resources Board chose instead to modify the program and to reserve the right to designate emissions limits for each air basin. The air-basin-wide agencies would be required only to allocate the designated emissions to planning subareas within each basin. They would not have to determine whether Federal and State air quality standards would be achieved and maintained. The ARB was in effect saying that the Clean Air Act left them no flexibility to avoid imposing intolerable burdens on the population of Los Angeles. They would rather see somewhat less stringent standards and higher emissions limits set for Los Angeles without the margin of safety inherent in the Federal air quality standards.

Although it is commonly agreed that the Los Angeles situation is rather unique in the United States, this example demonstrates that emission allocation is subject to some implementation problems for cases in which emissions are at or above the allocation limits. Clearly, it can lead to urban growth limitations in severe cases. Alternately, a time schedule for reducing emissions to the allocated levels may be included in the proposed allocation procedure.

This measure does not provide a clear breakpoint or transition from the implementation plan strategy for attaining the air quality standards to the maintenance plan strategy for maintaining them thereafter. This is probably an advantage of the measure for air pollution control agencies, but it does open an emissions allocation plan to unjust criticism of not being able to maintain standards, when the problem actually is that the implementation plan was inadequate in originally achieving the standards.

Another conflict centers on the transportation interface. As with emissions density zoning, spatially defined emission rates might force more spread development, resulting in an increase in vehicle miles travelled. Lower densities would inhibit the use of mass transit, thus compounding the problem. This is a speculative point, however, and needs documentation. It does, however, suggest that regional land-use and transportation plans providing for a limit on trip generation are required.

e. Practical Limitations. Practical limitations include:

1) The assignment of powers over land-use to a regional or State agency. Municipalities will feel that they have lost some control over land-use decisions to an agency removed from direct popular control.

2) The possibility the regional agency will make land-use decisions ignoring other important social needs. Comprehensive planning agencies will argue that "the tail is wagging the dog" in regional land-use planning, since air pollution control should be just one of the factors that influence regional land-use decisions.

3) The difficulty of defining an air shed or air basin. With a significant amount of "background" drifting into the region, the emission limitations would be subject to an error factor. Clearly, the strategy is best designed for well-defined air basins as is the case in California. Operational difficulties would be greater in the Northeast, for example.

4) The lack of an adequate institutional structure to deal with emissions rights. Economists contend that clean air has an economic value and can therefore be assigned a market price. The maximum allowable emissions would represent the supply of air rights for a region, the price of which would be determined by the demand. The supply of air rights would remain fixed, so that an increase in demand would cause an increase in the price of the assimilative capacity of the air. Conceptually, the air pollution agency could develop a market mechanism allowing for the transfer of the rights to highest bidder. A new source could also "buy" emission rights from an existing source who would then be required to commensurably reduce its emissions. The concept of "highest and best use" common in land-use law would apply,

with price as the decision criterion. It is unclear what effect such a mechanism would have in terms of land value and locational patterns in urban regions, but the impact would probably be significant.

4. Evaluation of Control Measure Effectiveness

a. Ability of Measure to Maintain Standards. Emission allocation should not be viewed as a one-time procedure. Continued monitoring and recalculation of the relation of emissions to assimilative capacity would be necessary. The logic of assigning a set quantity of emissions to each planning subarea would seem to encourage a refinement of the initial, rather crude allocation procedures. Ideally, roll back and modeling approaches should be combined to minimize error. The land-use-based emission factors would have to be reevaluated periodically to incorporate any changes in emission rates resulting from improved technology, fuel changes, etc.

As a technical procedure, emission allocation is a powerful tool. Politically, the problem of strict adherence to allocations would be the major difficulty. Retention of control at the State level would mitigate this political difficulty. States have all powers and only permit local government to take such actions as the state legislature sees fit. The problem is not completely eliminated and may even be magnified because State legislators represent local areas and act to serve local interests. As with land-use planning, the pressure to grant variances or increase allocations would be strong. A project review/environmental impact statement process would have to be conducted on a fairly detailed level in order to guarantee that allocations would not be exceeded.

b. Relative Efficiency. Among the variety of maintenance measures, emission allocation is an extremely efficient approach to maintain acceptable levels of air quality. A direct relationship is established between emissions and ambient air quality levels. Its major problem is that, although the logic is simple, the implementation of the procedures becomes a rather sophisticated process. Multiple levels of government are involved, and interaction between air pollution control officers and land-use and transportation planners and controllers must be close and continuing. In practice, the procedures would require well-trained professionals at various levels of government.

B. REGIONAL DEVELOPMENT PLANNING

1. Definition of Measure

Although technology-oriented control measures can go a long way toward reducing air pollution levels, there is no assurance that they will produce full compliance and continued maintenance of air quality standards. It is therefore necessary that air quality considerations be made an integral part of the regional planning process, and that constraints on development be shown in regional plans if they are indicated to be necessary to maintain standards. Regional development policies by themselves may have a significant effect on the location of pollutant emission sources and on the exposure of the populace to them.

From a practical standpoint, it must be recognized that regional plans, as well as community master plans, rarely carry any legal enforceability. They normally constitute a statement of the goals and aspirations of a region or community. In addition, generalized land-use objectives may be expressed in the form of a map commonly called the comprehensive plan or the master plan. Because they lack enforceability, comprehensive plans are dependent on measures such as zoning and other land-use ordinances for their implementation.

Notwithstanding, a comprehensive plan is a necessity if implementation measures are to be coordinated for the attainment of long-term land-use and environmental objectives.

Four principal elements of regional planning can be used to assist in maintaining air quality: a) regional form, b) open space planning, c) stationary source location, and d) transportation planning. Transportation planning is discussed in Chapter II, Section E.

2. Historical Review

a. Current Applications. A survey recently sponsored by EPA investigated the degree to which regional and town planning agencies incorporate specific air quality considerations into the planning process (ref. 1). The recognition of air quality as an important input or constraint to the formulation of regional plans is far from uniform. The survey found that only 36 percent of those agencies responsible for land-use planning explicitly consider air quality implications. Only 33 percent of the agencies responsible for transportation planning give explicit consideration to air quality. The significance of these findings is summarized well in the survey report (ref. 1):

> These figures are important because planning traditionally has had its greatest impact in land-use and transportation, and . . . these two activities have important causal links to air quality. Therefore, it is in these areas that planning could make a significant contribution to the task of controlling air pollution; or, on the other hand, it could cause significant problems through neglect.

b. Current Effectiveness. As indicated by the preceding survey results, air quality is infrequently included as a criterion in arriving at regional development decisions. Even those agencies that consider air quality rarely do so in a quantitative manner. There may be goals for clean air but rarely are there tools for evaluating the implications of alternative development proposals on air quality.

Thus, an objective observer would be forced to conclude that the consideration of air quality in regional planning has been largely ineffective.

c. The Vermont State Land-Use Plan. To control unplannned development and to protect State interests, State land-use plans have been implemented in Vermont, Maine, and Hawaii. Because the three States were similar in their approach, only one will be discussed here--the Vermont plan.

1) Background. Spurred by the problems some towns were experiencing as the result of large second home and ski resort developments, in 1969 Governor Dean C. Davis formed a Commission on Environmental Control to study the problems resulting from unplanned and rapid growth in Vermont (ref. 2). The Commission recommended that the legislature immediately adopt a statewide system of land-use planning and development regulation. The 1970 General Assembly accepted the Commission's recommendations and enacted Act 250 to establish a statewide process for dealing with land-use and environmental problems and the public service costs resulting from development.

Act 250 did two things. First, it established a system for reviewing applications for major subdivisions and developments across the State. District Environmental Commissions, composed of citizens appointed by the Governor, were established to review applications for development for compliance with 10 criteria. Nearly all significant development falls under the Act 250 review process (ref. 3).

2) Criteria. Before granting a permit, the district commission must find that the development meets the following 10 criteria (ref. 4):

a) Will not result in undue water or air pollution;

b) Has sufficient water available;

c) Will not cause unreasonable burden on an existing water supply;

d) Will not cause unreasonable soil erosion or reduction in the capacity of the land to hold water so that a dangerous or unhealthy condition may result;

e) Will not cause unreasonable highway congestion or unsafe conditions with respect to use of the highways existing or proposed;

f) Will not cause an unreasonable burden on the ability of a municipality to provide educational services;

g) Will not place an unreasonable burden on the ability of the local governments to provide municipal or governmental services;

h) Will not have an undue adverse effect on the scenic or natural beauty of the area, aesthetics, historic sites, or rare and irreplaceable natural areas;

i) Is in conformance with the duly adopted development plan, land-use plan or land capability plan; and

j) Is in conformance with any duly adopted local or regional plan.

A permit may not be denied solely for the reasons set forth in e, f, and g above, but reasonable conditions and requirements may be attached to alleviate the burdens created.

In addition to the District Environmental Commissions, Act 250 established an Environmental Board, also composed of citizens appointed by the Governor, to hear appeals from the decisions of the District Environmental Commissions and to promulgate rules and regulations to administer the Act.

Because the criteria of Act 250 were general and could not accomplish all of the purposes of Act 250, the legislature also directed the Environmental Board to adopt a series of three land-use and development plans. In addition, it was provided that the State plans were to be further implemented at the local level by authorized land-use controls such as subdivision regulations and zoning.

3) Interim Land Capability Plan. The first plan mandated by Act 250 was the interim land capability plan, which was basically a statewide inventory of: present land uses; physical limitations on development (e.g., steep slopes, shallow depth to bedrock); potential for agriculture, forestry, or mineral extraction; and unique or fragile areas, such as high elevations or wetlands. The interim land capability plan was adopted by the Environmental Board and approved by the Governor in March, 1972.

4) Capability and Development Plan. The second plan called for by Act 250 was the capability and development plan, which was enacted by the General Assembly in 1973. The capability and development plan was to be consistent with the interim land capability plan and to promote a coordinated, efficient and economic development of the State. The capability and development plan establishes policies and criteria designed to:

a) Minimize the adverse impact of development on lands with high potential for agriculture, forestry, or mineral extraction or with significant natural, recreational, scenic, or other resource value;

b) Protect the public from having to assume an unreasonable or or unscheduled burden in providing facilities and services to support scattered development; and

c) Safeguard the public investment in utilities, facilities building, and lands.

The policies in the capability and development plan were adopted to provide guidance in preparing the State land-use plan and town and regional plans.

5) The Land-use Plan. The final and most important plan mandated by Act 250 was the land-use plan, which failed to pass the 1974 legislative session, but will likely be enacted next year (ref. 5). The land-use plan is to be based on the capability and development plan. It is to consist of a map and statements of present and prospective land uses, which determine in broad categories the proper use of lands in the State whether for forestry, recreation, agriculture, or urban purposes. In drawing up the State land-use plan, consideration is to be given to duly adopted regional and town plans, capital programs, and municipal bylaws pertaining to land-use. However, once adopted, the State land-use plan and the capability and development plan are to be implemented at the local level by authorized land-use controls, such as subdivision regulations and zoning.

6) The Effectiveness of Act 250 (ref. 6). Although Act 250 has brought development close to a halt in some areas, this is relatively uncommon. In a study of the early period of the Act's administration, it was concluded that Act 250 had no significant impact on the rate of development and that most of the apparent slowing effect was attributable to the general state of the economy.

Examination of the permits processed by the District Commissions during the first 3 years of Act 250 indicate that only about 3 percent were denied. Although the Division of Protection is empowered to enforce the rules of the District Commissions, it has undertaken very few legal actions, preferring to use the threat of such sanctions to obtain compliance. The enforcement of the act is aimed much more at inducing compliance rather than punishing noncompliance. In considering applications for projects in which air pollution was an issue, the District Commissions have been quite free in imposing conditions on permit acceptance.

There can be little doubt as to the potential effectiveness of State land-use plans such as Vermont's Act 250 in controlling the air quality impacts of new development. It could well serve as an example of a control measure that more progressive States might adopt as part of the AQMP's.

3. Implementation

a. Mechanics of Incorporating Air Quality into the Regional Planning Process. To incorporate air quality considerations and constraints into the regional planning process, existing regional and community comprehensive plans must be scrutinized to determine their future compliance with air quality standards. Perhaps the best process for doing this is the use of environmental simulation models. If the analyses show that existing plans would result in future problems maintaining air quality standards, alternative plans should also be investigated to determine those more acceptable on the basis of regional air quality.

A recommended methodology for considering air quality in the planning process is presented in Guidelines for Air Quality Maintenance Planning and Analysis, Volume 4, Land Use and Transportation Considerations.

Conceptually, the air quality simulation process is very straightforward. Basic requirements consist of the location of emission sources and their emission rates, along with a method to relate emissions to pollutant concentrations. Ultimately, it is the concentration of pollutants in the air that is of vital interest.

In spite of this conceptual simplicity, the air quality modeling process is extremely complex. Using the future land-use plan as a base, estimates must be made of the magnitude of area and point source emissions throughout the urbanized area. This in itself is a highly complex task, since estimates must be made of the specific emission characteristics of developments that show up on long-range plans defined in rather broad categories. In addition, estimates of future control technologies must be made. The output of the stationary source emissions model should be a display of the location and emission rates of all significant area and point sources in the metropolitan area, for each pollutant of interest.

Based on the future land-use plan and the future transportation network, estimates must be made of the line source emissions from the transportation system. Since the emission rate of mobile sources is generally dependent on traffic flow rates, operating speeds, and trip origin-destination characteristics, the modeling of mobile source emissions is necessarily a complex task. It typically involves going through the complete transportation modeling process of trip generation, trip distributions, modal split, and traffic assignment to determine on a link-by-link basis the traffic flow rate and operating speeds. Because of the importance of cold-start and hot-soak emissions, trip-end information (i.e., the origins and destinations in each zone) should be utilized as well. Once the transportation system operating characteristics have been determined, emission factors must be applied to arrive at mobile source emissions. Most of this transportation simulation is required in the 3-C planning process.

As complex as the foregoing procedures are, they are only the beginning. The stationary and mobile source pollutants identified in the emission modeling process must be input to appropriate atmospheric dispersion models to translate raw emissions data to the parameter of real interest--concentrations of pollutants throughout the region. Because the emission and diffusion characteristics of pollutants differ, separate dispersion models must be exercised for each pollutant of interest. Particularly complex is the modeling of the photochemical oxidant formation, since it involves the interaction of hydrocarbon and nitrogen oxide emissions, their mixing in the atmosphere, and solar energy.

Although the environmental simulation process is very costly and highly complex, it does provide a framework for evaluating alternative long-range development plans. It permits the identification of subareas with unacceptable air quality, making it possible to prescribe remedies in the form of rearranging land uses. The simulation should ideally be an iterative process until an acceptable arrangement of future land uses is achieved. Perhaps the most realistic means of minimizing the high cost of simulation would be to include an environmental simulation element in the 5-year regional planning update cycle.

The following sections present techniques that can be employed to improve regional plans to bring them in compliance with ambient air quality standards.

b. Regional Form. Studies have been performed in several urban areas to relate air quality to regional development patterns. In a study of the Hartford, Conn. region (ref. 7), it was determined that a developed area elongated in a direction perpendicular to the prevailing winds would produce a much smaller area of unacceptable air quality than the long-range development plan in force at the time. However, the elongated development pattern did enlarge the area of questionable air quality.

A similar study in Chicago (ref. 8) indicated the desirability of concentrating development in relatively high density corridors bordered by green space. The presence of green areas adjacent to sources of pollution has been singled out as an important land-use factor in pollution reduction (ref. 9). A good example of this concept is the so-called "Wedges and Corridors" Plan for Metropolitan Washington, D.C.

Several studies have focused on the mobile source contribution to air pollution and the relative desirability of various urban forms.

Another study performed of Hartford (ref. 10) estimated an increase in average trip length of 22 percent for an urban form with a single major center over a form with balanced subcenters. However, due to the relative importance of trip-end emissions in comparison to running emissions, the air quality impact of trip-length reductions would be much less than 22 percent.

A similar study of Montgomery and Prince George's Counties, Md., found significant differences in pollutant production for various land-use and transportation network assumptions (ref. 11).

The importance of creating subregions with a balance of residential and employment opportunities has long been recognized by planners as a method of reducing travel requirements. Encouraging balanced subregions can potentially reduce running emissions significantly, although having little effect on cold-start and hot-soak emissions.

While a pattern of dense corridors or balanced subregions can apparently reduce overall urban area emissions, their effect on pollutant concentrations is not so clear. All other things being constant, lower population densities will generally improve ambient air quality. Lower densities imply a dispersion of people, commercial/industrial areas, and automobiles over a larger area, resulting in lower concentrations. However, as residential density decreases, trip length as well as trip generation can be expected to increase and the viability of mass transit is threatened.

With the current state of knowledge, it is difficult to generalize about the relative importance of reduced emissions of corridor or satellite city configurations compared with the dispersing ability of low density development. Important considerations in this tradeoff include prevailing meteorological conditions, as well as the existing socioeconomic and transportation system characteristics of the region.

With this dichotomy unresolved, a reasonable compromise is likely to be the alternating high density-low density radial corridors exemplified by Chicago's "Finger Plan" and Washington's "Wedges and Corridors."

c. Open Space Planning. The use of open spaces to act as a buffer between incompatible land uses has been a long-recognized technique of community planners. The ability of buffer zones to reduce the impact of air pollution is primarily related to distance (ref. 6). Although there are benefits to be derived from trees and vegetation, the primary benefit results from the decrease in concentration as distance from the pollution sources increases.

The use of buffer strips along high volume highways has been a particularly effective means of dealing with traffic noise and air pollution. Three types of benefits from roadway buffer zones have been identified (ref. 6):

1) Because development is prohibited adjacent to the roadway, there are no street canyons to concentrate pollutants, thereby improving dispersion of mobile source pollutants;

2) Buffer zones help to reduce human exposure to high pollution levels;

3) The presence of vegetation can further filter undesirable emissions.

Perhaps more important than the ability of green spaces to absorb certain pollutants are their beneficial microclimatological effects. Because much of the radiation is transformed into evaporative energy, the temperature over vegetated surfaces on sunny summer days may be 10 to 14 degrees cooler than over barren soil (ref. 6). This temperature differential reduces dust formation. Due to foliage transpiration, vegetated areas tend to have higher humidity than barren areas, also resulting in less dust formation and in more rapid settling of suspended particulates. Another significant effect of wooded areas is their wind-reducing character.

A variety of open space systems has been proposed based on their dilution potential (ref. 9). One analyst has suggested alternating rows of development and open spaces perpendicular to the prevailing wind direction. In general, however, the distribution of wind directions is quite variable and it is not effective to arrange land use based on prevailing wind direction.

Probably the best use of regional open space patterns is the creation of alternating development corridors and open space wedges radiating from the city center.

d. Stationary Source Location. Topics related to stationary source location are dealt with at considerable detail in other sections of this document. Therefore, this section will be brief and related specifically to their consideration in the regional planning process.

In the development of comprehensive plans, large new stationary sources, notable heavy industry and power plants, should be planned for areas that can accommodate the additional emissions without exceeding air quality standards. Since new industrial sites are usually quite restricted by the availability of utilities (rail connections, power, cooling water, etc.), the possible selection usually is from a few readily definable alternatives. Careful placement of industrial development can greatly reduce the impact of stationary source pollution on the community. To properly assess the location aspects of stationary source planning, the planning agency should also consider local climatology, topography, and meteorology. Consideration also should be given to the location of new major employment centers close to population concentrations to minimize travel and thereby reduce automotive emissions.

Because considerations other than air quality often prevail, it may be impractical to locate industry so as to minimize the impact of air pollutant emissions. In these cases, the impact of stationary source emissions can be reduced by controlling the development around the sources to ensure maintenance of air quality standards. When possible, buffer areas can be created around heavy polluters to discourage residential and commercial development. By controlling the development around sources in a manner that gives proper consideration to air quality, the exposure to pollutants can be significantly reduced. However, NAAQS must be maintained in the buffer areas if they are accessible to the general public.

Particular care should be taken in the siting of land uses sensitive to air quality. Among these sensitive receptors are schools, active recreation areas, housing for the elderly, and medical facilities. Because the users of these facilities are more susceptible to respiratory difficulties than the general populace, special care should be taken in their placement.

e. The Need for a Regional Approach. While there are air quality benefits to be derived from local planning efforts, it is imperative that the overall guidance be provided by a plan with a regional perspective.

In their report to the California Air Resources Board, Livingston and Blayney cited several problems with the use of local planning to achieve air quality objectives (ref. 12):

1) Oxidant is an area-wide pollutant, the product of a photochemical reaction between hydrocarbons and nitrogen oxides.

2) The impact of local land-use plans on local air quality cannot be gaged by a local effort because the proportion of local pollutants originating elsewhere in the air basin cannot be determined by local planning agencies.

3) The impact of local land-use plans on air quality in other portions of the same basin cannot be determined without a regional approach.

4) The impact of local land-use plans on traffic volumes cannot be evaluated without regional multimodal traffic models.

5) Local efforts cannot improve local air quality without comparable efforts basinwide.

In addition to these technical problems, three administrative problems were identified that would make implementation of locally prepared air pollution control measures difficult.

1) No effective administrative structure exists to resolve interjurisdictional conflicts.

2) Lack of a unified approach between local air quality control measures and regional transportation plans could result in the violation of air quality standards.

3) Where there is insufficient coordination between local planning agencies and local agency formation commissions, there may not be adequate analysis of the air quality impacts of proposed incorporations, annexations, special district formations, or expansion of special district areas.

As pointed out by Livingston and Blayney, these obstacles would seriously impair the effectiveness of air quality plans drawn up at the local level. Although local plans may be vital elements of a regionwide plan, the overall responsibility for a metropolitan area air quality maintenance plan must be at the regional or State level.

4. Effectiveness of Regional Plans in Maintaining Air Quality

Long-term regional planning can be an important element of air quality maintenance plans. The form of regional development can significantly affect the distribution of pollutants in the region. Open spaces can be used as buffer zones to encourage diffusion and reduce exposure. Controls can be exercised over stationary source placement and the land uses around stationary sources. Regional environmental simulation models can be used to evaluate future land-use proposals.

While these potentials exist, plans must be drawn up at the regional or State level, and they must be implemented forcefully if any of the potentials are to be realized. At the State level, the Vermont Land Use Plan offers considerable promise as a framework for ensuring air quality considerations in the long-range planning process.

C. EMISSION DENSITY ZONING

1. Definition of Measure

There is some variation in the description of emission density zoning in the literature. In this document, emission density zoning is defined as a regulation that requires emissions of a pollutant to be limited to prescribed levels within defined spatial areas. A limit is established in terms of an amount of emissions per area per time period, such as pounds of particulates per acre per year. Such a limitation may be administered by an air pollution control agency in conjunction with planners and zoning administrators.

Emission density zoning may be applied to existing and new sources. For example, it may be estimated that a heavy industrial zone could contain only those plants that would emit no more than 3 tons of total suspended particulates per square mile of lot size per day. A light industrial zone might have a ceiling of no more than 1 ton per square mile per day. So also commercial, institutional, and residential areas might have limits established.

The purpose of such a spatially defined emission limitation technique would be: a) to ensure that concentrations of pollutant emissions in a small area ("hot spots") would be avoided, and b) to maintain local and regional air quality at prescribed levels.

Emission density zoning could probably only be administered for stationary source emissions, so the measure is most applicable for sulfur oxides and particulate pollutants. There is no conceptual reason why emission density zoning could not be applied to other pollutants, such as carbon monoxide, hydrocarbons, or oxides of nitrogen, for the portion of total emissions produced by stationary sources. For example, the emissions of hydrocarbons from petroleum refining and storage might be regulated through emission density zoning. Rather, the problem is an operational one, centering on how the emission rates would be set. The determination of how to set emission limits will be discussed subsequently in this section.

Emission density zoning forms a framework favorable to implementation of another conceptual measure--the use of pollution or emission rights which are available in a predetermined fixed supply related to land area and transferable from one landowner to another. The total emission rights for a property would be equal to its area times the allowable emission rate per unit area under the emission density zoning regulations. In order to prevent the extreme concentration of emission rights at a few sources, the rights would probably only be transferable to adjacent properties or within a land-use area comprising a single zone.

2. Historical Review of the Measure

a. Current Applications of the Measure. Emission density zoning is not presently being utilized by air pollution or planning agencies in the strict sense discussed above (ref. 13). There is no current situation in which a comprehensive set of emission density zoning regulations containing emission limits per unit area per time period is actually being administered. However, there are two examples, Jefferson County (which includes Louisville), Ky., and Cook County, Ill., in which an emission density approach has been tried (ref. 14).

In order to promote the maintenance of air quality in Jefferson County, the Air Pollution Control Board developed a technique that places an overall ceiling per unit area on the maximum tolerable emissions consistent with air quality objectives. Both existing and new growth is incorporated within a common framework of emission estimation. The Board developed an emission density framework which states that any new or modified stationary source will be allowed to locate only if the emissions generated by the source, when added to the sum of emissions from all point sources within a 1-mile radius of the proposed or modified source, do not exceed 4,000 tons per year of particulates or 8,000 tons per year of sulfur dioxide. If it is anticipated that either of these annual emission densities would be exceeded, the required permit for construction would be denied. A permit denial can be rescinded if the applicant demonstrates to the satisfaction of the Board that the new source would not prevent the continued maintenance of NAAQS.

The determination of the amount of annual allowable emissions was made through use of the widely available Air Quality Display Model (AQDM). A set of emission rates was run through AQDM, with the 1-mile radius circle translated into a square of corresponding size, and the emissions treated as an area source. It was determined that 4,000 tons per year of particulates and 8,000 tons per year of sulfur dioxide were the maximum amounts that could be emitted from the square without violating air quality standards.

Clearly, the Jefferson County example is not emission density zoning in the formal sense. The case is interesting, however, as an attempt to apply emission limits that are tied to a spatially defined area. While the regulation does not prescribe allowable emission densities per unit time for fixed land areas or provide specific emission limitations for new sources, it achieves much the same purpose as emission density zoning.

The other area of interest is Cook County, Ill. The Cook County Environmental Control Department had emission density zoning regulations from 1963 until 1972. They were subsequently replaced by a process weight rate approach. The old regulations divided the county into three zones, based on zoning ordinance designations. Each zone had its own emission limits, in terms of pounds per acre of lot area per hour, with adjustments for tall stack heights.

The Cook County example is emission density zoning, in that the permit to construct and operate was tied to the meeting of emission regulations that were stated in terms of pounds per acre per hour. The regulations were administered by the Environmental Control Department. As such, the ordinance was not directly tied to the planners or zoning administrators.

Both the Jefferson County and Cook County cases illustrate the emission density zoning principle, in that both sets of regulations relate emissions to land area. Cook County, however, actually implemented an emission density zoning ordinance, while Jefferson County utilizes an emission density ordinance that aggregates all sources within a defined spatial area.

b. Effectiveness of the Measure. An indication of the measure's effectiveness is evident in the decision by the Cook County Department of Environmental Control to replace its emission density zoning ordinance with a point source emission limitation ordinance. Basically, the emission density zoning ordinance favored the larger and wealthier industries, that could more easily afford to buy additional land if they exceeded allowable emission levels with their existing acreage. Because the regulation discriminated against smaller industries, equity considerations were probably the major reason that Cook County rejected emission density zoning in favor of conventional source emission regulation.

The Jefferson County emission density ordinance, developed in 1972, is still too new for an analysis of its effectiveness. Emmission density zoning regulations have not yet been applied in a sufficient number of cases to make a firm judgment as to their potential utilization as air quality maintenance measures.

3. Implementation

a. Measure Implementation. The purposes of emission density zoning are twofold: 1) the avoidance of "hot spots" from highly concentrated groups of polluters, and 2) the maintenance of air quality standards. The Jefferson County, Ky., case discussed earlier is an attempt to avoid "hot spots" and thereby ensure acceptable levels of air quality.

Emission density zoning can be implemented in two different ways: 1) point source regulations can be maintained and emission density regulations adopted to cover only new or modified point sources, or 2) a set of emission density regulations can be used to replace point source controls. The probability of discarding point source emission regulations is relatively low for most situations. Therefore, the subsequent discussion focuses on utilizing emission density zoning as a supplement to point source regulations.

Basically, the use of emission density zoning would involve the following steps:

1) The determination of the emission rates, specified in amount per area per time period, that would maintain air quality at acceptable levels.

2) The development of regulations that encompass the emission rates established and that require each new or modified source to submit lot size data along with emission estimates.

3) The structuring of a feedback mechanism that would periodically assess air quality maintenance and, if necessary, alter the spatially defined emission rates. The existence of this feedback mechanism would require that the regulations contain a systematic procedure for changing emission rates.

The first step, determination of allowable emission rates, is the key to emission density zoning. The determination of emission rates involves the following steps:

1) The selection of land-use categories for which emission rates would be specified in the emission density zoning regulations.

2) The determination of the amount of land in the different categories that would be expected to emit at no more than the specified emission rates.

3) The calculation of the emission rates that would not violate air quality standards, by means of a proportional or atmospheric dispersion model.

The selection of land-use categories is a necessary first step to establishing emission density zoning regulations. In the work done to date, industrial control has been the prime objective of emission density zoning regulations. Industry has typically been divided into two classes, light and heavy. The light industrial classification has included SIC two-digit classes 20-25 and 34-39, while heavy industry has included SIC 26-33 (ref. 15). In some instances, other land-use categories have been added, such as commercial and residential (ref. 16). Because emission density zoning regulations have been for stationary sources of particulates and sulfur dioxide, the emphasis on industrial land use is to be expected.

Theoretically, emission density regulations could encompass the full spectrum of land-use categories found in metropolitan areas. Allowable emission rates could be determined for all the different land-use categories. However, the practical effects of establishing spatially defined emission rates for residential land uses could be to discourage higher density residential areas. The discouragement of higher residential densities through emission density zoning regulations may be counter to the planning and zoning objectives of the study area.

The second element in estimating the allowable emission rates in the regulations is determination of the amount of land assigned to the different categories. Argonne National Laboratory has run an atmospheric dispersion model estimating the air quality in the Chicago region (ref. 17). In one case, the model was run for total suspended particulates using current land-use and emission rates adjusted to meet Federal ambient air standards. It was estimated that heavy industry could emit 3.3 tons per day per square mile and light industry 0.85 ton per day per square mile. When the model was rerun with currently zoned land, the allowable emission levels dropped to 2.5 tons per day per square mile for heavy industry and 0.55 ton per day per square mile for light industry.

Since land zoned heavy or light industrial includes a larger portion of the study area than land presently in use, these results are understandable. Assuming that the air shed has a fixed assimilative capacity for a given set of meteorological conditions, there is a trade-off in the emission density zoning maintenance measure between allowable emission rates and the amount of land in the different land-use categories.

Thus, the specification of maximum emission rates by land use must consider the amount of available and classified land in each category. Assuming that point source regulations would be maintained for both new and modified sources when emission density regulations are introduced, the spatially defined emission rates would be applicable only to new or modified sources. As such, emission density zoning would act as a second check on the contribution of the polluter to air quality degradation.

Determination of the amount of land to be included in each category should consider the amount of land currently in use by category and the amount currently zoned for each use. All existing sources would be allowed to emit at levels controlled by point source regulations, providing that they did not subsequently dispose of plant property and, in doing so, exceed emission density limits. The land available for development in the different land-use categories would be the difference between current land-use area and current zoned land area.

An atmospheric dispersion model could then be run with the existing sources emitting at rates controlled by point source regulations, and the land available for development emitting at spatially defined rates. In this way, alternative emission rates for the different land uses could be tested. The rates developed would ensure that air quality would be maintained with development according to current zoning. Of course, other estimates of future growth could be used besides the zoning map. The general development plan of the study area is also a possibility, as is the use of urban development simulation models.

The final step in determining the allowable emission rates is their actual calculation. Either an atmospheric dispersion or proportional model is most suitable, although the Hanna model or others may also be employed.* The proportional model assumes that increases or decreases in pollutant emission density over an air basin result in a directly proportional change in the ambient concentrations of pollutant in that area (ref. 18). The proportional model does not simulate the transport or diffusion of the pollutant, and as such is the crudest and simplest technique to employ.

To use the proportional model, the maximum density of allowable emissions would be determined from existing air quality data, the air quality standard, and existing emission densities. The difference between this emissions ceiling and the expected future contribution of present sources would be the amount available for spatially defined emissions from new sources or modifications.

The basic relationships are as follows:

$$E_{TOT} = E_{EXS} + E_{EDZ}$$

$$E_{EDZ} = \sum_{i=1}^{n} A_i R_i + E_{NS}$$

where:

E_{TOT} = Total allowable emissions of pollutant in study area.

E_{EXS} = Estimated future emissions of pollutant by existing sources.

E_{EDZ} = Estimated future emissions of the pollutant from sources to be controlled by emission density zoning regulations.

A_i = Area of land in land-use class i.

R_i = Emission rate per area per time period for land-use class i.

E_{NS} = Estimated emissions of pollutant from new sources not regulated by emission density zoning.

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*Dispersion modeling is preferred over proportional modeling. The latter should by used only when sufficient data is not available to use a dispersion model.

This specification of basic relationships illustrates how emission rates could be calculated. Given an assumed distribution of land uses, the rates would be chosen so that the total amount emitted does not exceed a preset limit, E_{EDZ}. An infinite set of alternative emission rate combinations is possible if more than one land-use category is involved. The rates would have to be chosen through an analytic or simulation model. In the simulation approach, alternative sets of emission rates would be tried, and the one that is most reasonable in terms of some defined objective, such as reducing economic disruption, would be selected. In the analytic approach, mathematical programming could be used, provided that some criteria are established and that a satisfactory objective function is developed (ref. 19).

If an atmospheric dispersion model is utilized, determination of allowable emission rates would be based on maintenance of air quality standards as calculated at specified receptor points. All existing polluters would be treated as point sources and assumed to emit at future controlled levels. Emission rates would be established by treating the spatial distribution of expected future sources as area sources. Given a current emissions inventory and an estimate of future development, alternative emission rates for the different land uses could be entered in the model. With appropriate criteria for evaluation, the simulation of alternative sets of rates could produce one set superior to the others tested.

Emission density zoning requires more than the determination of emission rates by land use. Regulations would have to be developed to administer and enforce these spatially defined rates for the selected land uses. Specification of maximum emissions per area per time period would be made for new sources located in each land-use zone with possible allowances for the effect of stack height (see ch. III, sec. H, Stack Height Regulations). In no case will credit be given for stack heights above good engineering practice.

Proposed new sources would need to comply with multiple emission requirements and supply information which could be used to determine emission rates. Therefore, a permit system would be a necessary component of an emissions density zoning measure. The permit system would also facilitate coordination between the enforcement and planning agencies in administering the regulation.

Since point source regulations would also be enforced on the new installations (see ch. III, sec. A, New Source Performance Standards), the emission density zoning regulations would be a second checkpoint on new development. The regulations would have to specify that violation of either point source or emission density zoning requirements would be grounds for permit denial.

The procedure for granting any variances to the emission density zoning regulations would have to be carefully devised. Variances would easily disrupt implementation of this measure and seriously hamper maintenance of air quality. One possible means of providing for variances is the use of emission rights, through which an industry unable to meet the emission density zoning regulations could buy the rights to more emissions from neighboring landowners rather than purchase more land (ref. 20).

Finally, the development of emission density zoning regulations should include a feedback mechanism to allow changes in the emission rates. At any point in time, the rates set are a direct function of expected future development. Through continuous monitoring of the development of the study area, an information base could be developed to determine if the emission rates should change.

Since the emission rates apply only to new or modified sources, the actual development pattern for the area becomes the basis for the changing of the emission rates. With this kind of feedback mechanism built into the regulations, air quality maintenance is assured.

b. Conditions of Applicability. As previously discussed, emission density zoning can most effectively be used for control of stationary source emissions in industrial areas. Implementation would be aided if land uses were in separate, clearly defined zones--industrial, residential, commercial, and institutional--and future land use would also be assigned to well-defined areas.

Because of the extensive problems associated with emissions from existing sources in a complete conversion from individual source emission regulations to an emission density zoning approach, the latter measure is most often proposed as an overlying or secondary provision that would be used in addition to source emission regulations. As such, its impact on air quality maintenance is limited to restrictions on new or modified sources. Alternately, emission density requirements for existing sources could be phased-in over a long period of time.

c. Interactions with Other Measures. The primary interactions of emission density zoning are with point source controls, including stack height regulations and NSPS. Utilizing emission density zoning while maintaining point source regulations raises the question of how to handle the alternatives that may face an applicant for a permit to construct and operate. He may be denied a permit if the emission levels are too high under either or both of the two sets of regulations. Should the applicant not meet the point source regulations, certain changes could be made in the plant structure in order to ensure compliance. These changes in facility or operations would be required regardless of whether the emission density zoning regulations were violated.

However, if only the emission density zoning regulations were violated, the applicant would be faced with a set of alternative choices. First, the amount of emissions generated could be reduced through control equipment or process changes similar to those required by point source regulations. Second, the amount of land owned by the applicant could be increased in size. Third, the emission rights to other parcels in the land-use zone could be purchased, if this were acceptable under the regulations.

Beyond the already described interactions between point source controls and emission density zoning regulations, there is a further relationship between emission density zoning and emissions allocation procedures (described in sec. A, above, Emissions Allocation). Basically, emissions allocation procedures set emission lids for subareas of the AQMA but do not specify how these subareas should maintain emissions below the ceiling. It would be feasible for an AQMA to utilize emissions allocation techniques for subareas, and then have emissions within each subarea controlled by individual emission density zoning requirements.

d. Potential Conflicts and Negative Impacts. The spatial component of emission density zoning does suggest that its use would relate to community development objectives and plans. In particular, the use of emission density zoning tends to spread development to the extent that an industry would need to purchase enough surrounding acreage to meet the spatially defined standard. Lack of experience in implementing density zoning precludes any quantitative estimate of its impact on sprawl. Clearly, the potential disadvantages of lower density development must be balanced against the elimination of the "hot spot" problem and long-term maintenance of air quality.

Emission density zoning is best suited to industrial land uses. If this maintenance measure is restricted to industrial land use only, then the impact on total community development, in terms of restructuring densities of population and jobs, is minimal. A small impact in dispersing employment centers might occur in certain land-intensive, highly polluting industries.

The potential negative environmental impacts of emission density zoning center on the transportation and land-use interface. If spatially defined emission rates force more dispersed development, an increase in vehicle miles can be expected. Increased transportation source emissions is not a necessary and direct consequence of emission density zoning; much would depend on the actual locational decisions made as a result of emission density zoning regulations. However, the potential interaction should be taken into account.

e. Practical Limitations. There are two major political and social limitations on emission density zoning: 1) the ramifications of its spatial component on individual and group perceptions of steps necessary to maintain air quality, and 2) the interactions between land-use planners and air pollution control specialists. Should citizens object to or not understand an enforced relationship between air pollution and land area, administration of the emission density zoning regulations would be difficult. For example, emission density zoning has already been criticized as favoring the large polluter over the small one because large firms have more access to capital to buy any necessary additional land.

Under many circumstances, emission density zoning may not be perceived as inequitable. The concept of emissions limitations per unit land area as a feasible means of maintaining air quality standards may gain public and industrial support in areas where no apparent conflicts with community development goals are apparent. Unlike emission allocation procedures, in which the maintenance of air quality is left to local option in terms of who pollutes and how much, emission density zoning offers a predetermined, explicit set of regulations.

In addition to potential problems with citizen understanding, emission density zoning may be limited by the interactions between planner and air pollution specialist. While the enforcement of the emission density zoning regulations would probably be under the control of an air pollution control agency, zoning and regional development planning would probably be the responsibility of the planners and zoning administrators. The development and enforcement of emission density regulations would be difficult unless appropriate administrative linkages are established. In particular, the calculation of emission rates is dependent on a reasonably detailed estimate of future development. Thus, communication between planners and air pollution specialists must be established on a continuing basis in order to ensure that the appropriate estimates of future growth are used.

Economic limitations on the application of emission density zoning are primarily related to the additional costs imposed on the sources beyond those required by point source regulations. These costs could be in the form of buying additional antipollution equipment or changing processes, buying additional land, or perhaps purchasing emission rights from others. Argonne National Laboratory compared the cost of point source control and emission density zoning (without simultaneous source emission limitations) for Chicago, and determined that costs were approximately equal (ref. 21). Extrapolating from this example, it could be argued that in most cases the additional cost of emission density zoning over point source regulations would be minimal. However, in heavily developed AQMA's large polluters that are land-intensive may be seriously affected and may incur great additional costs. This result may not be unreasonable from an air quality maintenance perspective.

4. Evaluation of Control Measure Effectiveness

a. Ability of Measure to Maintain Standards. Emission density zoning is designed specifically to maintain air quality standards throughout a regional area such as an AQMA. Within the limits of accuracy of the emissions data and modeling procedures used in establishing its allowable emission rates, this measure should be totally effective in maintaining the standards either by itself or when used as a second emission limitation requirement in conjunction with conventional source emission regulations on stationary sources.

The measure requires some monitoring and feedback mechanism to provide for adjusting the allowable emission rates based on measured air quality data during subsequent periods, as the new sources are added to the zones. With the flexibility of such a feedback, any inaccuracies in the original emission rate development procedure can be corrected, and air quality maintenance can be ensured.

b. Relative Efficiency. Emission density zoning is only one of a number of maintenance measures that can be applied separately or in combination in AQMA's. As previously discussed, emission density zoning can be used in conjunction with point source regulations and could be a companion measure to emissions allocation procedures. In the framework constructed in this section, emission density zoning has no substitutes and hence cannot be directly compared with other measures. If, however, the option of using emission density zoning in place of point source regulations is considered, then the previously noted work at Argonne National Laboratory is pertinent. Their studies concluded that point source regulations and emission density zoning have similar costs and total emission reductions.

Emission density zoning and the emission density ordinance of Jefferson County, Ky., may also be compared. Both approaches are directed to the "hot spot" problem. If the "hot spot" is isolated and general air quality in the AQMA is not approaching the standards, either measure should be capable of maintaining standards. It is not clear that the Jefferson County ordinance would ensure air quality maintenance in the long run under present emission ceilings.

D. ZONING APPROVALS AND OTHER INDIRECT REGULATORY CONTROLS

1. Definition of Measure

As mentioned in the section on regional plans, they can be only as effective as their implementation. While the comprehensive plan may be useful in enumerating a region's goals and aspirations, as well as in identifying desirable future land development characteristics from an air quality maintenance standpoint, it is meaningless unless the plan is adhered to in the day-to-day decisions of municipal governments, which over the long term determine the shape of future growth. This section discusses techniques for plan implementation, identifies shortcomings in the implementation process, and also examines some of the more innovative approaches to land-use management across the country.

The land-use management techniques described in this section are primarily concerned with the larger issues of controlling and directing urban growth and only indirectly with the long-term maintenance of air quality. Nonetheless, they do have significant implications for air quality and should therefore be considered in the development of AQMP's. These techniques include:

- Zoning
- Subdivision regulations
- Capital facility ordinances
- Development timing controls
- Moratoria
- Transferable development rights
- Tax policy
- Capital improvement programming
- Critical environmental area control
- A-95 review process

The implementation measures discussed can be used to channel growth into areas that can contain it, while discouraging growth in already overburdened areas. Because the land-use management measures act primarily to restrict growth, they are not feasible techniques for AQMA wide application. It is assumed that an accurate picture of existing and anticipated conditions exists. Only if this is the case can the agency know where within the AQMA to discourage and where to channel development.

2. Historical Review

Many of the planning implementation measures cited above have received widespread use by community agencies. Zoning and subdivision regulations are found in the overwhelming majority of local jurisdictions. Capital facility ordinances, development timing controls, and building moratoria are not uncommon. Transferable development rights, in the form proposed, are a theoretical land-use management system without any historical record.

In spite of the widespread use of land management regulations, the incorporation of air quality considerations into them is far from a standard practice. A survey of local, regional, and State planning agencies indicated that only 41 percent of the agencies with responsibilities in land-use zoning make air quality a consideration (ref. 22). Only 13 percent of the subdivision regulations and 15 percent of capital improvement programs consider air quality. Forty-five percent of the agencies performing the A-95 review function reported giving consideration to air quality. Even when consideration is given to air quality, it normally is in a very qualitative manner.

As will be detailed in the following sections, the effectiveness of traditional land management regulations in achieving community land-use objectives is highly dubious. Their current effectiveness in promoting air quality objectives is even more tenuous.

3. The Implementation of Land-use Management Techniques

a. Zoning

1) Background. Zoning is probably the most widely used method of implementing community land-use objectives. The basis of most present day zoning ordinances is the U.S. Department of Commerce 1924 Standard Zoning Enabling Act (SZEA), which defines zoning as the division of a municipality into districts, and the regulation within those districts of (ref. 23):

- The height and bulk of buildings and other structures;
- The area of a lot that may be occupied and the size of required open spaces;
- The density of population;
- The use of buildings and land for trade, industry, residence, or other purposes.

The primary purpose of zoning is to ensure that land uses are properly situated in relation to each other, and that adequate space is provided for each land use. It allows the control of development density so that property can be adequately serviced by public facilities.

The legal basis of zoning lies in the police power of the State to enact legislation protecting the public health, safety, and general welfare of its citizens. Although the power to zone lies in the State legislatures, this power is usually delegated to the local communities.

Unfortunately, most cities adopted zoning ordinances before formal comprehensive plans existed. Subsequently, with the studied development of regional or community comprehensive plans, there have been many conflicts between land uses specified in area comprehensive plans and in zoning ordinances. Zoning ordinances can be effective in dealing with regional problems like air quality only to the extent that they are in conformance with regional comprehensive plans that are themselves consistent with air quality objectives.

2) The zoning ordinance. The zoning ordinance normally consists of a land-use map that defines the boundaries of various land-use districts, together with descriptions of the regulations attendant to each district. Major land-use types normally provided for include residential, commercial, industrial, and governmental. These major use types are normally subdivided into more specific classifications. For example, residential may be specified as single family, townhouse, and apartment. Commercial districts may be subdivided into shopping and office uses. Industrial classifications may be disaggregated into a wide range of types. Zoning ordinances normally include regulations on lot sizes, yard sizes, and the height and bulk of structures, and off-street parking and loading.

Taken collectively, the regulations normally contained in zoning regulations could significantly affect long-term air quality. The relative distribution of residential, commercial, industrial, and other zoning districts greatly affects the location of stationary and area pollution sources. The densities inherent in building size regulations are an obvious factor in the emission rates of air pollutants. The travel requirements attendant to various land-use configurations have a major impact on the generation of mobile source emissions.

3) Conventional zoning regulations with particular potential for reducing air pollution. As noted above, the general melange of zoning controls can have a significant effect on long-term air quality maintenance. However, certain elements of zoning practice may exert particularly effective influences on air quality. They are discussed in this section.

a) Development intensity regulations. Many of the regulations contained in zoning ordinances are directed at controlling development density, be it residential, commercial, or industrial.

Residential districts commonly include minimum lot sizes and maximum dwelling units per acre. Many communities have tried to preserve their rural character by zoning major tracts as large lot zones, often in the one to five acre range. Similarly, population densities are often controlled in multifamily residential areas by specifying a maximum number of units per area. Zoning requirements may also specify minimum setback regulations, i.e., distance from street line to building, and the percentage of a lot that may be occupied by structures. These types of regulations on the density and siting characteristics of residential units can influence air quality in the community. Population density limitations affect the concentration of pollutants from space heating and trip-end related mobile source emissions. However, their effect on regional emissions is not so clear, since they may encourage longer trips, additional trip-making and discourage the use of mass transit. They also have an undeniable impact on the direction of urban growth, since large lot zoning and other density regulations will alter the development economics. Regulations concerned with the siting of structures, e.g., height limitations, setback requirements, etc., can be used to encourage adequate dispersion of pollutants. The major objection to this class of regulations on residential development is their regressive impact on housing opportunities. As more constraints are placed on the development of residential land uses, housing may be beyond the reach of all but the affluent.

b) Parking requirements at new developments. Characteristically, zoning ordinances have required the provision of off-street parking facilities in commercial and industrial developments. The line of reasoning was that developers should be required to provide for the vehicle storage demands of the users of the development. While parking availability is clearly of considerable benefit to the building tenants and users, there is an emerging contrary philosophy. The availability of convenient off-street parking encourages trip-making by private automobile. In cities with extensive coverage by public transportation systems, it may be appropriate to discourage the development of off-street parking, thereby increasing the relative attractiveness of public transit systems.

c) Planned unit development. Increasingly, zoning regulations are giving special treatment to the developers of large-scale projects, under planned unit development ordinances. Most planned unit developments involve the construction of a variety of housing types, including apartments, townhouses, and single-family units on a single tract of land. Some projects involve the planning and construction of a complete community, including business districts and industrial plants.

Typically, the developer is required to meet overall density requirements and open space requirements. However, he may be given considerable latitude in the location and design of dwelling units within the tract. Houses may be clustered together on smaller lots, with the land savings used for common green areas.

Planned unit developments offer considerable potential for improving air quality. By their provision of extensive green space, they promote dispersion of pollutants. More significant, however, is the potential for reduction in trip lengths and the reduced need for automotive travel.

d) Transient (dual) zoning. A recent proposal by Murray Mantell has called for the establishment of so-called transient zoning: to cover all areas of a community that might otherwise be left unzoned (ref. 24).

It is argued that zoning decisions not in accord with master plans are much more likely to occur in relatively undeveloped areas that are in an unzoned category, sometimes indicated on zoning maps as "Agricultural Use" or "General Use". When the owner of a parcel in an unzoned area decides to develop his land, it is likely that the request for new zoning will be in the property owner's best interest, but not necessarily in the community's best interest. Because the legislative body rarely has a studied position on the best use of the parcel from a community point of view, it usually bows to the wishes of the applicant, particularly if he is an influential member of the community. The poor precedents become the basis for court decisions, thus making it difficult to establish enlightened planning procedures.

To overcome this vulnerability of unzoned land to be zoned to accomodate a higher density development than may be proper for the community good, it is suggested that a thoroughly studied "complete" zoning of the community in accordance with the comprehensive plan could be enacted. Because zoning is in force for the entire community, it is much less likely that "spot" zoning will occur, and there is a strong reinforcement of the concept that all rezoning should be in the public interest. Mantell recognizes certain shortcomings with "complete" zoning:

- It is difficult to plan too far in the future; therefore land that is many years away from development may be zoned in a manner that future developments would show to be detrimental.
- Landowners without development intentions would object to the higher taxables resulting from having their land rezoned to higher valued uses unless the concept of basing tax rates on present actual use (described below) is used.
- There would be objections to complete zoning by those who prefer to operate from the vacuum of an "unzoned" category where there are greater possibilities of pressuring early rezoning to a high profit category.

To overcome the major objections to complete zoning, Mantell proposes "transient" zoning which would be applied to all areas that might otherwise be unzoned. Transient zoning could be a prefix to all normal zoning categories in the community. The transient zoning applied to a particular tract would be subject to public hearings. The owner could request (without further public hearings) at anytime a change from "unzoned" to the ultimate use designated by the transient zoning, which would then become permanent. Taxes could be maintained as under an unzoned category, until developed, at which time the property could be revalued.

Transient zoning, as proposed by Mantell, is not directly related to air quality maintenance. Nonetheless, by encouraging orderly, controlled growth, transient zoning could be an important element in the land-use planner's efforts to control the long-range development patterns in the community and indirectly its air quality.

4) Zoning ordinance administration. The day-to-day enforcement of the zoning ordinance is normally carried out by a zoning officer. Nearly all zoning ordinances provide for the review board to hear appeals on the zoning officer's decisions, and to grant relief from literal enforcement of the ordinance in certain hardship cases.

Unfortunately, in many communities zoning ordinances have been rendered ineffective by poor enforcement, by improper use of special exception, by an overwillingness to grant variances and special use permits, and by the tendency of the legislative body to adopt unwise amendments based on the applications of individual property owners. Economic and political pressures have long led to abuses of variance and special exception procedures. In many communities, zoning ordinances are distinguished by their nonenforcement.

A candid evaluation of the administration of zoning ordinances was recently made by a prominent member of a Northern Virginia county's Board of Supervisors (ref. 25):

> It is not realistic to assume, nor to expect, that officials serving on these zoning boards are always going to rule with wisdom and the highest motivations. The outcome of a zoning case is often determined, not by objective, critical analysis of data, but by such irrelevant factors as the ambitions of a public official, personality clashes with the decision-making body, or even the time of day.

As pointed out by Mantell (ref. 24):

> All too often planning and zoning each go their own way, and the monthly meetings of the legislative body results in zoning changes and variances which are not in accord with the comprehensive master plan. The monthly meetings represent an ad hoc planning process which very quickly makes the original comprehensive master plan largely ineffective.

b. Subdivision Regulations. Subdivision regulations are locally adopted laws controlling the conversion of undeveloped land into building sites. They normally apply only when an existing tract is subdivided into two or more lots. Subdivision regulations govern the layout and design of new developments to ensure their compliance with the community plans for the area. This provision often includes requirements for the reservation of major street rights-of-way, parks, schools, recreation areas, and other public facilities planned for the future. There may be a set of requirements designed to ensure that the proposed subdivision will be coordinated with adjacent developments with respect to street connections, utility lines, drainage facilities, and perhaps open space reservations.

In addition to regulating the design of a subdivision and requiring the dedication or reservation of land for certain purposes, most subdivision regulations require the developer to construct or install certain improvements, often including streets, gutters, sidewalks, storm sewers, sanitary sewers, water systems, and other utilities.

Although it is difficult to draw any direct correlation between subdivision regulations and air quality, certain indirect benefits can be identified. Because it ensures a rational street system properly tied in with the community system, subdivision regulation may indirectly improve traffic flow and thereby reduce mobile source emissions. Perhaps more significant, subdivision ordinances, by virtue of their regulatory nature on developers, may in small measure reduce the rate of development.

When compared to other air quality maintenance techniques, subdivision regulation must objectively be considered of negligible impact.

c. Capital Facility Ordinances. Because of the rapid growth of many suburban jurisdictions, the need for capital-intensive facilities is increasing beyond the ability of the communities to pay for them. Rapid population influxes require additional schools, sewage treatment capacity, fire stations, and the entire array of municipal services. Because of the need for capital-intensive facilities, which require large fiscal outlays today, tax rates have characteristically been increased to the dismay of long-time residents.

An excellent example of this problem is provided by Sterling Park, Va., a large-scale development in rural Loudon County, currently at the fringe of the sprawling Washington, D.C., metropolitan area. The economic impact of Sterling Park was tabulated by the Virginia Farm Bureau Federation in a 1970 study which found that even though the 10,000 people then in Sterling Park paid $448,000 in property taxes, the cost of providing public services to them amounted to $2,400,000 annually. The difference was paid by the remaining 27,000 citizens of the county (ref. 26).

In an effort to control the public costs of urban development, Loudon County enacted a new article as part of its zoning ordinance. Article 12 requires developers to pay for the public facilities to serve the residents of their new developments. Other Northern Virginia counties are developing formulas that would require developers to pay for at least the major part of the public facility costs.

Montgomery County, Md., recently adopted an Adequate Public Facilities Ordinance, which requires that public facilities adequate to support and service a proposed development must be existing or programmed for construction within a defined time period before the Planning Board can grant approval of a Preliminary Subdivision Plan. The necessary public facilities and services include: public bus, rail, or other form of mass transportation, and/or roads adequate to carry the anticipated traffic generated by the proposed development; public sewer and water service, or private community systems meeting State and county standards; schools; police stations; firehouses; and health clinics.

The potential impact of capital facility ordinances is quite significant. By making the developer bear the full costs of his development or by requiring adequate public facilities to be in place, much of the speculative appeal of real estate development is reduced. Notably, in Loudon County a proposed 12,000 unit development was discouraged by the enactment of Article 12. Similarly, the requirements of Montgomery County's Adequate Public Facilities Ordinance permits planners to exert real influence over the location and size of new development. The ability of these ordinances to plan for long-term air quality maintenance in undeniable.

A significant objection to these ordinances is their effect on housing costs. Since any costs to the developer are ultimately passed on to the home buyer, the ability of low- and moderate-income persons to purchase homes may be seriously impaired. This objection is a real concern which must be weighed against environmental gains.

d. Development Timing Controls.

1) Petaluma, California. In an effort to control rapid urbanization as a suburb of San Francisco, Petaluma, Calif., adopted a

Residential Development Control System in 1972 (ref. 27). The system applied to all residential development except small-scale building, such as subdivisions with four or fewer lots, four or fewer multiple-dwelling units on a single lot, or a single family residential unit on a single existing lot. The system established a 17-member Evaluation Board comprised of a mix of planners, councilmen, businessmen, school board members, and citizens at large.

Annual quotas were established on a geographic basis based on the actual number of single- and multiple-family units called for in the General Plan. Residential developers were required to apply to the Board for a residential allotment. The Board reviewed all requests for each geographic area and published a listing based on the conformity of each development with a set of public facility and design criteria that included the capacity of existing public services to supply the needs of the development. The board then presented its evaluation to the city council, which had the power to award development allotments. In practice the system limited growth to 500 units per year, and it appeared that Petaluma was well on the way to controlling growth.

Then on January 17, 1974, a U.S. District Court ruled that the Petaluma law infringed on the constitutional right to travel. The ruling stated that "no city may regulate its population growth numerically so as to preclude residents from any other area from travelling into the region (ref. 28)."

2) Ramapo, New York. The Town of Ramapo in Rockland County, N.Y., was the focus of considerable national attention when, in 1969, the town amended its zoning ordinance to prevent the development of land for new housing unless the developer of such housing received a "special permit", regardless of the existing residential zoning of his land (ref. 29). The permit is granted only if the land to be developed is located in an area of the town that will be served by a minimum level of certain community facilities.

Installation of these facilities is scheduled in accordance with the town's Capital Improvements Program (CIP). The CIP covers the provision of sewerage, drainage, parks and recreation areas, roads, and firehouses. Permits are granted only if the land qualifies for enough points computed on the basis of values assigned by the proximity to the proposed development of the five capital improvement items cited above. The town adopted a capital budget for a future 6-year period for the development of these facilities. To govern beyond the initial 6-year period, the town adopted a capital plan for years 7 through 18 which established two priorities: facilities to be provided in years 7 through 12 and those to be provided in years 13 through 18. The town allows the owners of property with deferred development potential to apply for a tax reduction, in recognition of its reduced development value.

If the developer agrees to provide any of the facilities himself, he may advance the time of development if he then earns the required points for a special permit.

Since the development timing approach represents a powerful land-use control measure, it can be effective as a tool in guiding the location and intensity of future growth. Its major drawback is the potentially regressive effect on the housing market.

e. Moratoria. Many communities, faced with sudden large increases in in-migration, have enacted various moratoria on sewer connections, water connections, or building permits to enable the formulation of plans for accommodating growth in an orderly and rational manner.

Petaluma, Calif., prior to enacting its residential Development Control System, imposed a freeze on development, rezoning, and annexation that lasted more than a year. The purpose of the freeze was to postpone major land-use decisions until basic goals and policies could be set (ref. 27).

Several jurisdictions in Metropolitan Washington have instituted moratoria of one form or another. Fairfax County, Va., in January 1974 passed an "interim development ordinance" which banned the construction of all subdivisions, townhouses, and apartment and industrial complexes not already approved by the county, for a period of 18 months (ref. 30). The purpose of the building ban was to halt growth while the county prepared a Planning and Land-Use System (PLUS), a complete overhaul of the county's land-use laws and procedures, including a new master plan, a total rezoning of the county, and a 15 to 20 year program for the construction of public facilities. The effectiveness of the Fairfax County ordinance is dubious, as 54,000 homes and apartments could be built during the ban because they received prior county approval (ref. 30). Because of this lead time required for the ordinance to become effective, any slowing of the growth rate will probably occur after the 18-month ordinance has expired.

Neighboring Prince William County, Va., had a moratorium imposed on new sewer connections in a major sanitary district by the State Water Control Board between September 1972 and August 1973. Again, because of the connections already approved, there was little noticeable effect on the county growth rate. Whatever effect there is may be evidenced in the future, but it has not been immediately apparent. Similar moratoria imposed in Montgomery and Prince George's County, Md., have met with similar outcomes.

In summary, the effectiveness of temporary moratoria in controlling growth is unclear. While moratoria must be viewed at best as temporary holding actions, their effectiveness is not evident.

f. Transferable Development Rights. A comparatively new approach to land-use planning is the replacement of existing zoning administration with a system of Transferable Development Rights (TDR). Advocates of TDR systems point to the failure of current zoning practice to implement community land-use plans and objectives. As one environmental newsletter has stated (ref. 31):

> ...many Americans, whether they live in a city row house or suburban split level, have come to distrust the zoning process. By and large, it hasn't resulted in well-planned communities--and if you doubt that, look around you. It has not guaranteed the owner of a half-acre suburban paradise that he won't see a high-rise blossom behind his back yard fence, nor the city dweller that traffic-generating commercial uses won't be permitted to congest his streets.

An objective observer can hardly argue with this conclusion. The same source goes on to say that:

> Zoning has not done the job because there is money to be made--big money--in getting land zoned for the "highest and best" economic use. County boards and commissions are notoriously susceptible to the persua-

> sive powers of attorneys promising big-revenue developments that turn out to be more burden than benefit to tax-paying homeowners.

In an advocacy document on TDR prepared by Fairfax County Supervisor Audrey Moore, the basic principles of TDR are spelled out (ref. 25):

- Separation of land and use of land for purposes of regulation.
- Equal compensation for all landowners for development potential of a plan at no cost to the public.
- Taxation of property by use, while keeping to the standard of fair market value for assessment purposes.
- Provision for purchase of land for public facilities at minimum cost.
- Elimination of lengthy procedures involved in government approval of development.
- Provision of an economic mechanism for total approach to population distribution.

The basic objectives of TDR could be accomplished through the following procedures:

- The community would adopt a comprehensive master plan that would establish the total number of residents projected to live in an area and the total number of commercial/industrial needs projected for that area.
- The community would determine how many development rights are required for each kind of residential and commercial/industrial development. Public facility use, farm use, conservation and recreation use, and utility lines would require no rights.
- The government would assign each property owner of record his rights in direct proportion to the number of acres of land owned, subtracting any development that may exist or development rights considered by the community to have been vested.
- To initiate development, the landowner would file transferable rights equal to what is required for that development with his site plan or subdivision plan.

On assignment to particular parcels of their share of development rights, those rights would be made freely transferable from one parcel to another. In order to build, the developer must not only buy a parcel of land, but also must purchase enough development rights.

When rights are sold or transferred for development, the land they were assigned to becomes open space at no cost to local government.

The political difficulties in implementing a TDR system are considerable, and it is unlikely that it could be enacted in the near future. Nonetheless, its potential for removing land-use planning decisions from the ad hoc process characteristic of zoning administration merits serious attention. Perhaps in the next decade, TDR may find its way into the land-use planning tools available for controlling urban growth and improving long-term air quality.

g. Tax Policy. The potential impact of tax policy on shaping future growth can be significant. Two concepts are particularly noteworthy: 1) Vermont's capital gains tax, and 2) the deferral of real estate taxes while land is used for low intensity purposes.

Vermont, in addition to the provisions of Act 250, has enacted a tax reform program which includes a relatively high capital gains tax on land development. The tax rate is inversely related to the duration of the land holding. Thus, the buying of tracts for short-term subdivision and resale is particularly discouraged. While it is impossible to quantify the impact of this legislation, it clearly exerts some braking effect on rapid development, which in turn has an indirect effect on air quality maintenance.

Another commonly used tax policy is the taxation of agricultural or undeveloped land based on its use, rather than on market value. Thus, the farmer who chooses to continue farming a tract that is well placed and zoned for development would be taxed not on the value of the land as a development site but rather on its agricultural use. An additional development disincentive can be provided by deferring the difference between the tax on use and the tax on market value until the time of development. Thus, a developer would be further discouraged by the cumulative tax deferrals that he would have to incur in order to develop. These tax reduction and deferral policies provide some incentive for the landowner to continue using his land for low intensity purposes. Further, the deferral scheme actively discourages development.

Because they can provide an incentive for low intensity land-use, tax policies can have a significant impact on air quality maintenance planning.

h. Capital Improvements Programming. As mentioned in previous sections, certain jurisdictions are including the availability of capital facilities as an important criterion in evaluating development proposals. Development timing controls, adequate public facility ordinances, and other local policies make capital improvement availability a condition of development.

While these measures make capital improvements a direct factor in development decisions, capital improvement programs can drastically shape development even in the absence of the more powerful ordinances. As summarized by Croke, et al. (ref. 32):

> Public land development or public works has great effect on shaping and directing urban growth through construction of transportation systems, public institutions (e.g. state colleges and hospitals), and utilities. In the past, public works have usually been constructed in response to development or market pressures; recent years have brought an increasing awareness of the impact of public investment decision on establishing an infrastructure for private decisions. The role of a new highway or sewer system in influencing development direction has clearly been recognized, although not fully utilized.

i. Critical Environmental Areas. Many communities have adopted Critical Environmental Area (CEA) Plans, designed to preserve environmentally sensitive tracts from incompatible development. The State of Virginia provides an example of criteria for use in identifying CEA's (ref. 33):

- An area that has unusual natural or manmade features worthy of protection by State or local governments. The features may include historic sites, special wildlife habitats, areas possessing unique geological or physical characteristics, and areas well suited for future park development.
- A natural area that is critical to an ecological system. Areas might include flood plains, tracts with severe topography, or low wetlands.
- Certain natural, scenic, or historic areas that are presently endangered because of the activities of man.

- An area appropriate for public use through future acquisition by State or local agencies.
- An area that can be considered to contain a primary State resource, including wildlife, minerals, and agricultrual production.

While preservation of air quality has not been considered as a justification for designating critical environmental areas, there would appear to be sound reasons for doing so. The second and third criteria listed above would be particularly appropriate for air quality considerations. It is unlikely that designating critical environmental areas could affect regional air quality unless such designations were of substantial area. However, as a tool in controlling "hot spots", this process may be appropriate.

In Virginia, development is not prohibited in CEA's but higher standards are applied to ensure compliance with the intentions of the CEA system.

j. The A-95 Review Process. A previous section presented the need for a regional approach to plan development. Pollution does not respect geographic boundaries. The impact of locally generated pollutants is not confined to the area in which they are produced. One community has little control over the development policies of adjacent communities. Because of the potentially conflicting air quality goals of neighboring communities, a need exists to mediate interjurisdictional conflicts.

In the absence of a regional authority, local communities acting in their own self-interest can easily subvert the goals and objectives of regional growth policies and regional AQMP's. It has become apparent that in many metropolitan areas, neighboring jurisdictions are vying with each other to determine which one can make itself least attractive to new residents, while actively seeking light industry for its tax benefits. The result has been inequity between jurisdictions. Thus, one municipality may attract a great deal of light industry and at the same time effectively discourage residential development to serve the employees of the industry. The result is that neighboring jurisdictions must carry the financial burden of providing residential services, while being unable to reap the high taxables of industry. A notable attempt to correct this disparity has been undertaken by the Metropolitan Council of the Twin Cities. In 1971 the Minnesota legislature passed a law requiring each local government in the Twin Cities region to contribute 40 percent of the net growth of commercial and industrial property tax valuations to the Council for redistribution to various local governmental units according to population and need (ref. 32).

The logical agency to review local planning decisions for compliance with regional plans is the regional A-95 review agency. The Office of Management and Budget (OMB) Circular No. A-95 provides the structure for implementing sections of three acts: Title IV of the Inter-governmental Cooperation Act of 1968, section 204 of the Demonstration Cities and Metropolitan Development Policy Act of 1966, and section 102(2)(C) of the National Environmental Policy Act (ref. 34). The common goal of these sections is to ensure the coordination of Federal programs and projects with State, regional, and local programs. State clearinghouses have been established in every State, as well as in most metropolitan areas, to administer the provisions of the A-95 Circular. Perhaps the most significant accomplishment of the A-95 process has been the establishment of a structure for interjurisdictional cooperation and comprehensive planning. Unfortunately, all too often the member governments tend to view the clearinghouse role not as influencing regional policy, but rather as a communication forum and an insurance device for the continued flow of Federal funds to local governments (ref. 35).

Although the A-95 process has established a structure for considering air quality maintenance at the regional level, because only federally funded projects are subject to review, many large-scale projects with significant air quality implications escape review.

The need for regional review of local planning decisions for conformity with regional plans is great. The political problems involved in so doing are also great.

4. The Effectiveness of Land-use Management Techniques in Maintaining Air Quality

The effectiveness of land-use management techniques in achieving community land-use objectives has been unimpressive. Since air quality considerations are at best secondary considerations in land-use management, with few exceptions, the effectiveness of these techniques in maintaining air quality has been marginal. The anticipated usefulness of individual techniques for air quality maintenance is summarized in Table II-1.

In spite of this rather dismal record, the prognosis offers hope. The new environmental ethic which has emerged in recent years has encouraged the strengthening of land-use management techniques. Capital facility ordinances, development timing controls, and building moratoria have all been developed in recognition of the failure of traditional zoning controls. The use of capital improvements programming to direct future growth is now being recognized. The A-95 review process offers a potential framework for regional consideration of air quality. The Vermont Land-use Plan, discussed in a previous section, provides a model for the statewide or AQMA-scale consideration of air quality impacts of development.

While land-use management as an air quality maintenance measure has been relatively ineffective in the past, its potential is considerable. Under the aegis of a regional or statewide land-use plan with enforceability, the various community ordinances can have an impact on long-term air quality. However, without a regional review function, it is doubtful whether these ordinances could be effectively implemented.

E. TRANSPORTATION CONTROLS

1. Description of Transportation Controls

"Transportation controls" is the generic term applied to a diverse group of measures that, either directly or indirectly, can potentially reduce emissions from motor vehicles by one of two broad approaches:

- Reduce the pollutant emission rate per vehicle-mile of travel (VMT), or
- Reduce the total number of VMT.

Although certain stationary source control measures, such as service station vapor control, are considered transportation controls within the context of the strategies submitted in implementation plans, only those measures associated with reducing motor vehicle emissions are described here.

Table II-1. Summary of selected land-use management measures that may affect maintenance of air quality standards

Measure	Purpose of Measure	Examples of current applications	Method of implementation	Effectiveness in maintaining air quality	Sources and pollutants affected
Zoning	To control development of a city or county	Nationwide	Local ordinances	Controls density of development but may not have significant effect on air quality	Stationary sources--TSP, SO_2, HC, NO_x
Subdivision regulations	To ensure subdivision is compatible with adjacent areas and provide for necessary facilities	Nationwide	Local ordinances	Minimal effect on air quality, rational street system may minimize vehicle emissions	None significantly
Capital facilities ordinances	Requires developers to include cost of sewers, parks, schools, etc., in development costs	Loudon County, Va. Montgomery County, Md.	Local ordinances	Higher costs may reduce buyer demand and inhibit growth of new sources of emissions	Automotive and stationary sources--all pollutants
Development timing controls	Set quotas for new developments	Petaluma, Calif. Ramapo, N.Y.	Local ordinances	Direct effect on air quality by reduction of growth of new sources	Automotive and stationary sources--all pollutants
Moratoria	Temporary prohibition of new development	Fairfax County, Va. Prince William County, Va.	Local ordinances	Because of the temporary nature, may have no long-term effect on air quality	None significantly
Transfer development or pollution rights	Each parcel of land is allocated a pollution right which can be used or sold by the owner	None	Local ordinances	The emission allocation can be set to the level required to maintain air quality standard	Stationary sources--TSP, SO_2, HC, NO_x
Tax policy	To control rate of development at a desired level	Vermont	State law	Direct effect on air quality by restricting growth of new sources	Stationary sources--TSP, SO_2, HC, NO_x
Capital improvements programming	To control location of new developments	Nationwide	Provision of public funds by local or state government	May not control growth in total emissions but can control where new sources are located	Automotive and stationary sources--all pollutants
Critical environmental areas	To protect areas from significant deterioration of air quality	Virginia	Local ordinances State laws	Measure can be used to maintain air quality in selected portions of AQMA	Automotive and stationary sources--all pollutants
A-95 review process	To ensure cooperation between adjoining political jurisdictions	Minneapolis-St. Paul, Minn.	Designate regional coordinating agency	Can be used to protect against hot spots created by poor distribution of sources	Automotive and stationary sources--all pollutants

Many of the transportation controls that have been proposed or implemented are listed in table II-2. This tabulation is not meant to be all inclusive. Because of the wide range of available measures, a plan for control of automotive emissions may be tailored or designed specifically for problem areas within an AQMA, whether they are extensive or extremely localized. However, measures designed to reduce oxidant concentrations must be areawide. Proper selection from these numerous measures can minimize the social and economic impacts that are inevitably linked to all transportation controls.

It should be noted that gasoline rationing is currently considered to be infeasible and that it can be assumed that existing transportation control plans based primarily on gasoline rationing will not result in attainment of NAAQS.

Transportation control plans were initially developed to attain standards over the relatively short-term range of 2 to 5 years, and employed measures aimed at reducing both emission rate and VMT. However, for maintenance of standards over the longer range, measures that reduce the emission rates from in-use vehicles will become less effective unless new control or vehicle-power-technology breakthroughs occur, because measures such as retrofit and gaseous fuel conversion will be inapplicable to post-1975 model year vehicles. As a result, transportation control strategies needed for maintenance will have to rely heavily on measures that reduce VMT. An inspection/maintenance (I/M) program is an important control measure because not only is it capable of achieving large emission reductions (8-12 percent CO and HC), but also it helps ensure that the emission reductions claimed for the Federal Motor Vehicle Control Program are in fact achieved. An I/M program will assist the State or local government in implementing an effective antitampering program and can help ensure that owners of vehicles subject to recall under Section 207(c) of the Clean Air Act have the required work done prior to the periodic inspection. The Clean Air Act specifically anticipates that I/M programs will be included in the implementation plans of those regions that have automobile-related air quality problems.

Many of the measures designed to reduce VMT have already been employed by traffic agencies for the purpose of eliminating undesirable congestion in high traffic density areas. It is important that trans-

Table II-2. Transportation control measures

Measures to reduce emission rates	Measures to reduce VMT
Federal Motor Vehicle Control Program (FMVCP) Retrofit devices Vacuum spark advance disconnect with low idle Air bleed to intake system Oxidation catalysts Inspection/maintenance Gaseous fuel conversion Traffic flow improvements Better highway and interchange design Signal progression One-way streets Reversible lanes Driver advisories Loading regulations Staggered work hours	Traffic restrictions Street closings Traffic-free zones Partial traffic restriction Limited access zones Idling restrictions Gasoline rationing Traffic restraints Parking bans Parking supply management Parking surcharges Road use or entry charges Priority treatment for carpools Increased gasoline taxes Increased vehicle registration fees Bikeways Traffic avoidance Restricted road building Urban area bypasses Control of urban development; e.g., strategic planning and planned unit development Four-day work week Mass transit improvement Rapid rail Community rail Improved bus service Reduced mass transit fares Express bus lanes Employee mass transit incentives

portation control measures have obvious accompanying benefits such as reduced congestion, time and money savings to commuters, better public transportation services, or energy savings, because experience has shown that significant restrictions of personal mobility are not likely to be accepted solely to improve air quality. The public reacts negatively to imposed limitations on travel because many have immediate and substantial impact on life style, whereas air quality maintenance usually has only long-term, intangible benefits.

It should be emphasized that not all VMT reduction measures result in limits on personal mobility or loss of individual freedom of choice. There are three general means of limiting traffic: restriction, restraint, and avoidance. Traffic restrictions include all methods of preventing traffic by physical obstruction or act of law, thus representing direct impairment of mobility. Traffic restraints are methods designed to influence travel choices, such as parking charges or free bus service. They, too, limit mobility, but without affecting individual freedom of choice. Traffic avoidance aims neither to prevent nor to dissuade people from fulfilling travel desires, but rather to avoid the birth of the desires in the first place. Traffic avoidance appears to be the most desirable long-range approach to VMT reduction. Because traffic avoidance measures deal with trip purposes and the relative locations of homes to trip destination points, they overlap considerably with land-use planning activities.

The most promising transportation control for producing lasting reductions in automobile use is probably improved mass transit. In the major urban areas where long-range transportation controls will be needed to maintain standards, only about 14 percent of work trips are now handled by mass transit (ref. 36). Cities that provide high quality mass transit have demonstrated that this mode of travel can attract much higher levels of ridership, particularly if auto use is comparatively difficult or expensive.

2. Historical Review of Transportation Controls

a. Current Applications. As mentioned previously, numerous kinds of transportation controls have been employed for the purpose of relieving congestion or improving traffic flow. In some instances, air quality data taken before and after the implementation of these controls have documented air quality improvement that accrued as a secondary benefit. Selected examples of these existing transportation controls are listed in table II-3.

Transportation control plans designed to produce specific air pollutant emission reductions have been adopted for 30 AQCR's, by the responsible State air pollution control agencies and/or EPA. Although the control measures were proposed to achieve the air quality standards by mid-1975 or within 2 years thereafter in cases where an extension was granted by the Administrator, very few of the proposed measures had been implemented by mid-1974. Part of the deliberation in carrying out these transportation control plans can be attributed to the need to evaluate medium- and long-term impacts of existing gasoline shortages, higher prices, and energy conservation programs on travel patterns before initiating further travel restrictions and restraints. Another reason for the delays in implementing transportation controls has unquestionably been the extensive opposition to these plans by affected interest groups and citizens (ref. 37).

Transportation control measures most often proposed in the promulgated plans are summarized in table II-4. The numbers presented in this table are intended only to show the relative prevalence of the measures and may not reflect recent revisions in various transportation control plans.

There are few examples of measures already in progress. Three are described below: the inspection/maintenance program for the State of New Jersey, free bus service in downtown Seattle, and the exclusive bus/carpool lane on I-95 in the Washington, D.C., area.

The State of New Jersey in July 1972 initiated an idle mode test for CO and HC emissions, using nondispersive infrared analyzers as part of the required annual automobile safety inspection (ref. 38). However, compliance was voluntary until February 1974 in order to provide a period of familiarization and training. The test is conducted statewide at all 34 of the State-operated inspection stations with a total of 68 inspection lanes. The cost of performing the emissions and safety test (not including program administration), approximately $2.00 per vehicle,

Table II-3. Examples of existing transportation controls to reduce traffic congestion

Transportation control	Cities presently employing this control
Traffic-free zones (refs. 39, 40)	Over 100 worldwide cities, including Tokyo, Vienna, Essen, Leeds, The Hague, Oldenburg, Munich, Athens, Bologna, Brussels, Florence, Ravenna, Rouen, Rome, and Verona
Partial traffic restriction by erecting physical barriers to subdivide the center city (ref. 41)	Approximately 24 U.S. cities, including New York City (temporary), Atchison, Fresno, Kalamazoo, Miami Beach, Minneapolis, and Providence
Partial traffic restriction by erecting physical barriers to subdivide the center city (ref. 41)	Bremen, Goteborg, Bologna, Liverpool
Idling restrictions (ref. 42)	Stockholm
Parking ban in central city (ref. 39)	Marseilles
Parking supply management (ref. 39)	Bologna, Newcastle, Hamburg, The Hague, London, and Glasgow
Improved mass transit service (refs.42, 43)	Seattle, Atlanta
Reduced mass transit fares (ref. 43)	Atlanta, St. Louis
Exclusive bus/carpool lanes (ref. 40)	Metropolitan New York (Long Island Expressway, I-495 in New Jersey), Boston (Southeast Freeway), Washington, D.C. (I-95), San Francisco (Bay Bridge toll booths)
Entry tolls and permits for center city (ref. 39)	London
Urban area bypasses	Most major U.S. cities
Staggered work hours (refs. 39, 42)	New York, Munich, Cologne, Bonn

Table II-4. Transportation control measures proposed in promulgated plans

Transportation control	No. of State plans	No. of EPA plans	Total no. of plans*
Inspection/maintenance	15	25	31
Traffic flow improvements	7	18	24
Catalytic retrofit	6	15	16
Other retrofit	9	13	21
Parking restrictions	6	24	28
Pricing policies	5	3	8
Mass transit improvements	10	8	13
Additional stationary source controls	11	24	30
VMT reduction	4	4	8
Motor vehicle exclusion areas	2	2	4
Gaseous fuel conversion	2	0	2
Carpool locator	4	6	9
Gasoline limitations	0	11	11
Motorcycle restrictions	0	7	7
Idling limitations	0	1	1
Selective vehicle exclusion	1	9	10
Employer mass transit incentives	0	10	10

*In some AQCR's, the State and EPA have proposed separate or differing controls of the same type. These numbers are intended only to show the relative prevalence of the measures and may not reflect recent revisions in various transportation control plans.

Source: State Air Pollution Implementation Plan Progress Report, January 1 to June 30, 1973. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Publication EPA-450/2-73-005. September 1973.

is covered in the annual vehicle registration fee. Allowable emission rates were originally set to provide for a 10 percent failure rate of tested vehicles, which were then required to obtain maintenance and be retested. Later air quality data indicated that more stringent transportation controls would be required to achieve the air quality standards in two portions of the State, so the vehicle emission standards are scheduled to be reduced to levels that should result in a 20 percent rejection rate after July 1, 1974, and finally to a 30 percent failure rate.

During the first evaluation of the inspection program, a sampling of vehicles that failed the idle mode emissions test had average repair costs of $22.50 (ref. 44). In an economic analysis, part of this cost should be attributed to routine maintenance that would have been performed in the absence of the maintenance requirement.

The Metro Transit of Seattle began offering free bus service in a 105-block downtown section of the city in September 1973. Because the free rides are all on portions of existing bus routes that pass through this designated area, no additional equipment or operation costs are required to provide the service. In fact, this new program replaces a downtown 10-cents-per-ride shuttle bus system that was operated at a deficit by Metro; consequently, with a $64,000 1-year subsidy from the City of Seattle, the service is not a financial burden to Metro.

The incentives to start such a program were primarily to ease traffic congestion and to reduce pollutant emissions in the critical center city area. The 5,400 daily bus trips through the area now carry an estimated 11,000 downtown riders, almost twice the former 6,000 shuttle bus riders. With ridership still increasing, the free service has the potential to decrease downtown auto traffic by almost 20 percent during the daytime hours, based on an origin/destination survey of the area (ref. 45). Favorable publicity from this program is also credited with recent increases in patronage on the entire Metro Transit system.

The exclusive bus/carpool land on I-95 (Shirley Highway) in the Northern Virginia suburbs of the Washington, D.C., area was designed and constructed under an Urban Mass Transit Administration (UMTA) demonstration grant in 1970, and was originally to be discontinued after 2 years as that segment of I-95 was widened and modified. After the opening of the exclusive bus lane, counts on this corridor showed a modal shift during peak traffic periods from 27 percent transit riders in June 1970 to over 40 percent in June 1972. After the UMTA grant expired, efforts to convert the bus lane into a reversible lane open to all traffic were strongly opposed by bus commuters and other citizen groups. The reversible center lane was retained for exclusive bus use, partially due to the need of the transportation control plan for the AQCR to demonstrate substantial reductions in VMT.

As a result of gasoline shortages during the summer months of 1973, the bus lane was also opened to cars with four or more occupants to encourage carpooling. A $250 fine for illegal use of the lane was imposed ($1,000 for a second violation) and the requirement for minimum number of riders was strictly enforced. The most recent counts available for January 1974, show that the single bus/carpool lane carried 11,117 persons during the morning peak period while the other four inbound lanes carried a total of 11,841 persons. The breakdown by mode was 43 percent bus, 6 percent carpool, and 51 percent private car; average auto occupancies for the two road sections were 4.94 and 1.15, respectively. Travel times averaged 23 minutes less for the linehaul portion of the trip on the bus/carpool lane in the morning, and 20 minutes less in the evening. These advantages make door-to-door travel time and convenience of a bus or carpool comparable to that of a private car for commuters in this corridor.

b. Effectiveness of the Measure in Current Applications. Existing transportation controls have widely varying impacts on emissions and air quality, due in part to the broad range of different controls that fall into this category. Differences in effectiveness of individual transportation controls are even more pronounced if impact is measured on a regional scale, because some of the actions, such as inspection/maintenance or retrofit, result in emission reductions throughout a metropolitan area, while many others have a significant impact only in a single area or corridor of the region. The measures with a localized effect must produce air quality improvements specifically in areas where air quality maintenance is a problem if their full effectiveness is to be achieved.

The New Jersey inspection/maintenance program recorded impressive average reductions on vehicles after their initial servicing: about 60 percent for CO and 57 percent for HC (ref. 44). However, these values apply only to the portion of vehicles serviced (10 percent failure rate), and to the initial inspection/maintenance cycle; it does not consider degradation in emission rates that occur after the servicing, which diminishes its effect. The potential reduction in years following the initial servicing is lower because the cars are not as much out of adjustment. Potential reduction also decreases in succeeding years due to the replacement of older cars having higher emission rates with new, controlled vehicles. Therefore, the total emission reductions in regional CO and HC emissions claimed by New Jersey and EPA for the statewide inspection/maintenance program in the years 1972 to 1977 are not applicable to future periods for which maintenance controls may be needed. The percentaoe reductions in regional motor vehicle emissions, as shown in table II-5 may remain fairly constant in future years. Accurate estimates of effectiveness of inspection/maintenance programs should be based on calculations that include the following factors (ref.44):

- Total vehicles in the AQMA in the year of interest
- Distribution of vehicle population by age
- Average annual mileage for each age class
- Emission factor by age class in the year of interest
- Emissions without an inspection/maintenance program
- Fractional reductions in emissions after servicing, by age class
- Deterioration rate between inspections, by age class
- Anticipated failure rate.

The other two existing transportation controls described above both have traffic impacts in only a portion of their metropolitan areas. They also have the common characteristic of reducing emissions by a combination of reductions in VMT and increases in average speed, plus the non-air-pollution-related benefit of reduced traffic congestion.

The free bus service in Seattle has not been in operation long enough to accurately assess its impact on VMT or air pollution levels. According to the origin/destination survey data for downtown Seattle, this action may divert a substantial percentage, up to 20 percent, of

Table II-5. Estimated emissions reductions from the inspection/maintenance program in New Jersey

Estimated by	Projection year	Assumed inspection failure, %	Regional reductions in motor vehicle emissions		Regional reductions in total emissions	
			CO	HC	CO	HC
New Jersey Bureau of Air Pollution Control	1974	10	3	6	NA	NA
	1975	20	6	8	3	2
	1977	30	8	10	4	2
U.S. EPA	1975	45	10	11	NA	5
	1977	45	10	11	4 to 6	4

NA = Data were not available.

daytime auto trips in the center city area where the highest traffic densities and CO concentrations occur, thus reducing maximum 8-hour CO measurements.

The exclusive bus/carpool lane on I-95 in Washington, D.C., is reducing the number of vehicle trips into the city and back by about 3,500 per day, or about 33 percent of total traffic volume on that portion of I-95 and 10 percent of total traffic volume in that corridor during the peak traffic periods (ref. 46). The impact of these trip diversions on local air quality should be proportional to the traffic reductions, or possibly even greater because of increased average speeds with less traffic. This program definitely proves the potential for mass transit and carpooling to attract a far greater share of suburban commuters.

3. Implementation of Transportation Controls

a. Procedure. It may be assumed that control agencies and motorists in AQMA's that might implement transportation controls as a maintenance strategy would already be somewhat familiar with them. Transportation controls for air quality maintenance probably will be used only in some of the 38 metropolitan areas that already have transportation control plans to achieve air quality standards. This is because areawide reductions in emissions projected through 1985 as a result of the Federal Motor Vehicle Control Program (FMVCP) should exceed the growth in emissions due to increased VMT even in the fastest growing metropolitan areas. Hence, if an AQMA has not exceeded air quality standards for motor-vehicle-related pollutants in 1975 or prior years, it is unlikely that it will do so between 1975 and 1985. Also, any new localized violations of the CO standards should be prevented at least in part by the indirect source review procedure.

Once the need for transportation controls to maintain air quality has been established, the extent of the area projected to exceed the standards without a maintenance plan should be determined. If only a localized area is affected, controls different from those needed for areawide emission reductions should be considered. For instance, traffic flow improvements or vehicle rerouting can be very effective in abating localized problems.

Specific measures should then be reviewed in consultation with regional and local transportation planners, and possibly the public, to select those most appropriate for more thorough investigation or preliminary design and costing studies. In most respects, the selection of appropriate transportation controls is synonymous with selection of maintenance measures for the comprehensive maintenance strategy, since the transportation control "measure" is actually a diverse group of controls for the motor vehicle emission category that could be considered individually as maintenance measures.

Retrofit, inspection/maintenance, and gaseous fuel conversion maintenance measures probably would be designed by air pollution control agencies. For measures other than these three, the design of the actual traffic control system should be given over to transportation planners, with the agency responsible for the AQMP providing only such input constraints as the percent reduction in emissions or VMT needed, the area over which the controls should act, and the time frame for initiating the controls. This transfer of the design functions should minimize several major problems encountered in developing the original transportation control plans (ref. 47):

- Transportation controls in conflict with regional transportation planning and local development goals,
- Inadequate evaluation of mobility limitations resulting from the controls,
- Statements of broad control objectives without adequate consideration of implementation problems or times.

After the design phase, it may be appropriate to also delegate implementation of the provisions directly to another agency, such as a State department of transportation or highways. Since the responsibility for a State-submitted AQMP rests ultimately with the Governor, assignment of plan implementation to a State or local agency other than the one that directed its development is certainly feasible.

The generally long lead time available before the need for transportation maintenance measures provides the opportunity for incorporating revisions or modifications into the transportation and land-use planning process. It also allows for greater use of more acceptable and less disruptiv measures, such as expanded mass transit service and planned unit development.

Detailed implementation steps for specific transportation controls are too voluminous to be included here. The Strategies and Air Standards Division has prepared and published documents describing retrofit, inspection/maintenance, and parking controls. Additional documents will be developed and published as required. Previously published transportation control plan resource documents should be used until such time as new ones become available.

b. Conditions of Applicability. Transportation controls include a whole spectrum of methods to reduce motor vehicle emissions. As such, this maintenance measure is considerably more flexible in application than other measures and can be utilized in some form for any case in which air quality standards are exceeded primarily due to motor vehicle emissions.

The conditions most favorable to application of specific transportation controls are described in several publications (ref. 39, 41, 42) and in the EPA documents mentioned above. However, transportation controls should not be prescribed primarily because of their applicability from an air pollution control standpoint, but rather based on their acceptability as modifications to the urban transportation system. Therefore, the criteria for applicability are that the proposed measure does indeed reduce motor vehicle emissions in the area of concern and that it can be integrated into the urban transportation system with minimal adverse effects.

c. Interaction With Other Measures. Transportation controls interact with other measures having an impact on motor vehicle emissions. In particular, transportation controls are affected by the indirect source review process and by energy conservation measures for gasoline. Indirect source review generally precludes the need to otherwise consider carbon monoxide concentrations at the very localized, individual-facility level in transportation control plans. Instead, these plans can address air quality maintenance for the entire areas or corridors for which standards are projected to be exceeded. The review procedure and the control plan do not have any potential conflicts or overlapping, since indirect source review is concerned with the traffic-inducing facilities and the transportation controls concentrate almost exclusively on regulation of the traffic.

Most programs to reduce motor vehicle emissions through gasoline conservation would also reduce VMT. However, the reductions from fuel conservation measures could not be confined to primary areas of impact as they could with transportation controls. In effect, a regulatory gasoline conservation program could be thought of as one transportation control that could be applied with others to obtain the required reduction in motor vehicle emissions.

Regional development plans or control measures that encourage dispersed development tend to increase VMT and motor vehicle emissions and are therefore counterproductive to transportation controls. Urban sprawl also increases dependence on the automobile and decreases the potential for expanded use of mass transit, one of the most desirable methods of reducing VMT.

d. Potential Conflicts With Community Development Plans. Since transportation is one of the most important factors in urban development, controls on transportation have tremendous potential impact on all aspects of community development, with those that seriously reduce mobility being in conflict with many community plans and objectives. In evaluating possible transportation controls, these impacts on a city's economy, population growth, employment, and location of new development should be considered carefully. If proposed construction of a single urban highway link warrants a comprehensive impact assessment under the NEPA requirements for EIS's, a transportation control plan for an entire urban area deserves, comparatively, a multiyear major study of its potential impact on community development.

Transportation controls are probably most compatible with community development if they are implemented gradually over an extended period of time, and if they are incorporated into the decisionmaking process for transportation system improvements. Urban transportation systems are always imperfect; they are continously being evaluated and upgraded to meet changing mobility needs.

The increasing use of motor vehicles for transportation is creating many problems other than air pollution: disproportionate consumption of petroleum fuel supplies, noise, traffic congestion, accelerated encroachment of development around cities into former rural and agricultural areas, and injuries and deaths from automobile accidents. These other problems deserve equal attention in determining changes in the transportation system, and certainly controls imposed to reduce air pollution emissions should not intensify any of these problems. For example, a regulation requiring nighttime deliveries by trucks may reduce peak traffic period emissions significantly, but if the measure is projected to cause unacceptable increases in nighttime noise levels in residential areas near major delivery points, it should not be implemented. Most transportation controls also produce improvements in these other automobile-related problems.

Because transportation controls deal with mobile sources, they can result in the high air pollution levels being displaced rather than eliminated. The closing of some streets in the center of Rome caused worse traffic jams near the bloakades than had previously been experienced in the cordoned area (ref. 39). The evaluation of potential controls for specific areas should include a check on resulting traffic changes in other parts of the AQMA.

e. Practical Limitations.

1) Social acceptability. This discussion of transportation controls has emphasized throughout that the public will not accept reduced mobility, which would significantly alter their daily life styles, in exchange for the intangible benefits of maintaining air quality standards. The best means of gaining public support is to provide a positive alternative to the present condition, such as improved mass transit service or a comprehensive traffic flow improvement plan for the downtown area that includes restrictions on vehicle entry during certain periods. These improvements in the urban transportation network that simultaneously act to reduce motor vehicle emissions should be developed under the auspices of transportation planners with the cooperation of air quality specialists.

Another means of obtaining public support for traffic restrictions or restraints is to emphasize the accompanying benefits of the controls, such as reduced congestion, time or money savings to commuters, better public transportation services, or energy savings.

2) Economic feasibility. All of the transportation controls listed in table II-2 have been shown to be economically feasible in advantageous applications. Obviously, retrofit of all motor vehicles in an AQMA would not be feasible, but retrofit of just pre-1968 vehicles might be. Cost-effectiveness of the different controls also varies widely, depending on specific applications and characteristics of the urban area.

Some new rapid transit alternatives are economically prohibitive as transportation system improvements, so they obviously are not feasible air quality maintenance measures. For example, underground rail systems such as San Francisco's BART or Washington, D.C.'s Metro probably could not be initiated in other cities at current construction costs and escalation rates. The Urban Mass Transit Administration is now seeking innovative mass transit designs rather than encouraging new underground rail systems.

Any strategy that proposes to use fiscal restraints and disincentives to reduce auto travel also risks being opposed or rescinded because of its discriminatory effects on the mobility of low-income groups. Many of the proposals for fiscal restraints, e.g., gasoline taxes or higher auto registration fees, have been accompanied by plans to reduce or rebate these costs for low-income individuals to minimize the regressive characteristics of such measures. However, the scaled charges or rebate plans make implementation of these controls much more complex and possibly impracticable.

4. Evaluation of Control Measure Effectiveness

a. Ability of Measure to Maintain Standards. This measure consists of a diverse group of controls, many of which can be applied concurrently. Thus, a proper mix of these controls should be capable of maintaining air quality standards for most conceivable growth patterns in an AQMA. The only circumstance under which transportation controls may not have the capability of maintaining standards without the simultaneous application of other measures is the instance of a large percentage of the CO, HC, or NO_x emissions coming from nonautomotive sources. In this situation, even restrictive transportation controls may not offset increases in stationary source or other nonautomotive emissions.

Transportation controls promulgated in implementation plans are projected to reduce CO and HC emissions in particular areas of several AQCR's by as much as 50 percent, although these reductions are yet to be demonstrated. The estimated impacts of several of the individual controls are summarized in table II-6. In a few instances, these estimates may overstate the potential reductions attainable with these controls in the 1975 to 1985 period, due to the much lower emission rates of post-1975 motor vehicles and to reductions that may already have been obtained through transportation controls.

Table II-6. Estimated motor vehicle emission reductions from individual transportation controls.

Time to implement	Transportation control	Estimated reductions in motor vehicle emissions, percent
Short term 2 - 5 years	Inspection/ maintenance	4 to 15 (ref. 48)
	Retrofit	10 to 60 for those vehicles retrofitted (ref. 48)
	Gaseous fuel systems	Less than 15
	Traffic flow techniques	Less than 20 in area affected
Medium term, 5 - 10 years	Bypassing through traffic	Less than 5
	Improvements in public transportation	Less than 5
	Motor vehicle restraints	5 to 25 in area affected
Long term 10 - 20 years	Work schedule change	Less than 3
	Control of urban development	Not estimated

Source: Institute of Public Administration, Teknekron, Inc., and TRW, Inc. Evaluating Transportation Controls to Reduce Motor Vehicle Emissions in Major Metropolitan Areas. Environmental Protection Agency. Research Triangle Park, North Carolina. Publication No. APTD-1364. November, 1972.

Estimates of emission reductions from transportation controls can be calculated more accurately with data specific to the AQMA, using procedures described in appendixes A through G of EPA's publication APTD-1364, Evaluating Transportation Controls to Reduce Motor Vehicle Emissions in Major Metropolitan Areas. Controls for which estimating procedures are described are:

- Retrofit
- Gaseous fuel conversion
- Traffic flow techniques
- Public transportation improvements
- Motor vehicle restraints

In the 1975 to 1985 period, average motor vehicle emissions will be reduced by 55 to 65 percent by the FMVCP without maintenance plans. Therefore, the need for transportation controls to maintain standards that have already been achieved should be limited to isolated problem areas (rather than AQMA-wide). Cities that required large emission reductions by transportation control plans to initially achieve the standards may need to retain many of their regionwide transportation controls throughout the 10-year maintenance period.

b. Relative Efficiency When Compared With Other Measures. Transportation controls encompass all the measures used to control motor vehicle emissions, so there are no alternatives to this measure if the problem is strictly motor vehicle related. However, if the standards are projected to be exceeded in an area as a result of both motor vehicle and stationary source emissions, then a comparison of measures is pertinent. For implementation plans, transportation controls generally were to be considered only after all feasible stationary source controls had been employed. This priority does not persist in developing maintenance plans, and the decision should instead be based on a comparison of cost-effectiveness and social impacts of the alternatives, as described in volume 2. Transportation controls have the advantage of being considerably more flexible than stationary source controls with respect to the geographical areas over which they are to be applicable.

F. EMISSION CHARGES

1. Definition

Two types of emission charges have been suggested from time to time as control measures for air pollution. One is a charge on each point source, proportional to its emissions, that would be set at a rate related to the type of emission, the type of damages attributable to that pollutant, and the concentration of that pollutant in the ambient air of the AQCR. The other is a tax on the emitters of a pollutant, either at a flat rate for the entire nation or a rate adjusted for each AQCR.

Both types of charges are designed to internalize the external costs of pollution, that is, to place an economic burden on the individual or firm responsible for the emissions that will make the cost of pollution a part of the cost of doing business or of consuming goods. It is argued that the disposal of the residuals of combustion, industrial production processes, and consumption, such as automobile operation, imposes a cost on the general public but is free to the pollution source. Therefore, to provide an economic incentive for control, these costs must be allocated to the pollutant sources, who then will find it economical to control emissions and who will, in turn, include these costs in prices to be paid by the beneficiaries of production rather than by the general public.

Effluent charges on the sources of water pollution can be charged in proportion to the cost of water treatment downstream from the source. This procedure obviously does not apply to air pollution emissions. Air pollution emission charges might be set at rates that are above the cost of control and thus induce polluters to reduce emissions. Because 100 percent control is not possible for most sources of pollutant emissions, any such system of charges will tend to ration the remaining emissions to those sources for which control costs are highest or available control technology is least effective.

At least in principle, emission charges could be set by an air pollution control agency for each source of each pollutant, individually, within an AQMA. If such a system were based on real estimates of the social costs attributable to emissions, the least cost of control, or other optimizing criteria, it could conceivably provide a highly flexible set of economic incentives for the achievement of an optimal emission pattern. However, such criteria measurements are not readily available to policy makers and the more likely prospect is that such a system would be considered discriminatory, arbitrary, or capricious and hence unconstitutional. It might also be used as a means of requiring best available technology that in turn might well not approach optimum in other senses. Given the administrative and legal problems of such a system and the lack of effective criteria for application, the remainder of this section will be addressed to the more likely control measure of taxation.

2. Historical Review of Measure

Historically, taxation has been one of the means used by government to control the behavior of individuals and businesses. The use of taxation as a means of controlling pollution has been widely discussed in current economic literature. (See, for example, ref. 49. This article presents a good summary and evaluation of the economic theory of externalities and the theoretical applicability of taxes to control pollution.) A tax on sulfur emissions has been proposed in Congress, but has not received serious attention as yet. One variation of a tax on sulfur emissions was the subject of a recent study performed for EPA (ref. 50) As a control measure, taxation is yet to be tested in practice.

3. Implementation

a. Procedure. A tax could be applied to emissions of any of the pollutants now subject to standards. The tax could be either a statewide flat rate tax or graduated at different rates for classes of sources or geographical areas. Whatever the form, however, the general effect is assumed to be to induce controls at a level such that the incremental cost of removing the last unit of pollutant emission from the gasses released to the atmosphere equals the tax rate. Thus, controls are applied at that level where the combined cost of the control system and tax is least. Tax payments continue to be made on the uncontrolled emissions.

This statement of the way an emissions tax would work is, of course, an oversimplification. An electric power company might well find, for example, that the cost of controlling sulfur oxides emissions did not vary continuously over the entire range of possible control rates. Instead, there may only be a small number of possible control techniques at very different control efficiencies and costs. The control cost functions may consist of very large steps. As a result, large shifts in the rate of tax on sulfur emissions might not induce a change in company behavior until the level is reached that causes the company to move from one step to another on the cost function. Producers would also have to base their control decisions on other factors as well as the cost function. The time over which investment would be amortized could be an important consideration. The possibility that new and more economical technology might soon be available could cause a firm to pay the tax while deferring investment in control equipment. Other factors also influence business decisions, but the effect of a tax may still be approximated by the cost minimization concept given above.

If the reaction of all sources of a pollutant to a tax could be specified in advance, the tax could be set at a level that would achieve any desired emission level possible with current technology. In fact, comprehensive control cost functions cannot be specified with accuracy at this time and the noncost factors in business decisions are not amenable to advance estimation. However, if a desired level of total emissions can be specified, it is theoretically possible to apply a tax on a trial and error basis, adjusting the rate until the desired result is achieved.

A procedure that would take out at least a part of the uncertainty as to the reaction of all sources of a pollutant to a tax is one that specifies a level of control which must be met and a decreasing tax if emissions are below the level resulting from the control. The specified level of control should be selected based on the overall air quality requirements of the area and an analysis of the control cost function. If the control cost functions consist of discrete steps, the minimum control should be at one of the step levels.

In the development of an emission charge procedure, special consideration must be given to those industries having little or no competition. For example, power plants usually are allowed a specified percent profit by the Public Utilities Commission. In such a case management may choose to ignore pollution control, pay the emission charge, and pass on the increased cost to the consumer. Providing the requisite legal authority can be obtained, such a situation may be avoided by a sliding profit margin based on emissions. Similar considerations apply to other sources that may have no competition within their trading area.

b. Conditions of Applicability. Emission charges can be applied to any point source and pollutant within the AQMA. Its greatest applicability is for pollutants and sources having a wide range of potential control techniques; e.g., sulfur oxides and particulates.

c. Interaction With Other Measures. A tax could be used in place of emission standards to achieve a predetermined level of pollution in the ambient air, e.g., to achieve the NAAQS. It is more probable, however, that a tax would be used to reinforce the effect of emission regulations such as those promulgated in the SIP's. Taxes could conceivably be used in conjunction with other control measures as well. For example, tax rates could be varied by zones when emission density zoning is employed, or a high tax rate on emissions of one pollutant might be used to discourage the location of additional firms emitting that pollutant.

d. Potential Conflicts With Community Development Plans. Because emission charges would be normally imposed by the political jurisdiction responsible for the preparation and implementation of community development plans, any potential conflicts can be resolved during the development phase. Should conditions warrant the application of emission tax or charge to only selected portions of the AQMA, close coordination with the community development plans is essential so that the impact of the tax on growth and development is consistent with the desired growth and development patterns.

Emission tax or charge provides a source of revenue that could be used in the community development process. However, air quality maintenance considerations should be the deciding, if not only, factor in the decision to impose a tax or charge on emissions.

e. Practical Limitations. The apparent advantage of using taxation as a control measure is that it provides for different behavior by firms with different processes, control costs, or size of operations.

By making the degree of control to be achieved by each source economically determined, the tax approach permits those with high control costs to apply less control than those for which control is more economical and small producers to control at different efficiencies than large ones. In principle, therefore, taxation provides a control measure that should provide a much closer approach to an economical allocation of resources than arbitrary emission standards, while providing equivalent areawide ambient air quality.

There are, however, a number of other aspects of taxation as a control measure that should be considered:

1) The method of control is not specified. It may, for example, be desirable to require a stationary combustion source to control emissions by the use of stack-cleaning devices rather than by fuel switching, even if the latter were more economical.

2) If a tax is paid on the uncontrolled emissions, this increases the cost of achieving that level of control induced by the tax. Some tax will be paid by each source in each instance.

3) If tax rates are set initially by trial and error and if they are subject to change from time to time, this introduces a degree of uncertainty into business decisions that may, at least partially, defeat the intent of the measure. A firm will not undertake investment in costly control equipment without reasonable assurance that it will be acceptable over a reasonable period of time. The wrong investment could lock it into a control level that would later require it to pay very high taxes. There would be a tendency to hold back on control investment to see where the tax will be set during the trial and error period. But if that occurs, the successive approximation process cannot reach the appropriate level.

4) A question arises as to the appropriate use of the revenue generated. This is a problem quite apart from the control measure itself.

5) Enforcement of a tax measure poses much the same monitoring problems as does the application of standards, plus the administration and enforcement problems of the tax itself.

6) Another question is that of constitutionality. Any tax measure will have to meet the standards for nondiscrimination and reasonableness. The question of constitutionality is not presently pertinent but will arise when any specific proposal is put forth.

7) It appears likely that taxes could be levied at the State level to control air pollution. However, it is not clear whether the rate of tax can be varied from region to region. Taxes levied by the authority administering a single AQMA would almost certainly require enabling legislation from the State government and, perhaps, change in the State constitution.

4. Evaluation of Control Measure Effectiveness

a. Ability of Measure to Maintain Standards. Emission charges in themselves do not result in the maintenance of NAAQS. They are used with other control measures and contribute through such measures to the maintenance of standards by providing economic incentives to predetermined levels of control.

b. Relative Efficiency Compared to Other Measures. An evaluation of the relative efficiency of emission charges cannot be made because they are not used to the exclusion of other measures but rather in a supplementary role.

G. TRANSFER OF EMISSION SOURCE LOCATION

1. Definition of Control Measure

The transfer of emission source location measure involves the optimum use of terrain, meteorology, and geography of an AQMA from an air pollution viewpoint. The influence of a given emission source upon the air quality of an area varies with its location. This control measure is one that explicitly considers source location and urges relocation for minimum air quality impact upon all new construction or expansion.

While this measure has the potential of being effective when applied to all source categories, it is especially applicable to power plants. However, because judicious relocation could result in a significant improvement in local air quality within an AQMA, all source categories should be considered as potential candidates for this measure.

2. Historical Review

a. Current Applications of the Control Measure. This measure has often been used in power plant siting. A contemporary example of the measure is the construction of major power plants--including the world's largest coal-fired generators--in the remote areas of the Southwest that will ultimately supply 60 percent of their output to Southern California, hundreds of miles removed (ref. 51). The electrical output of power plants can be transported long distances with only modest losses. In certain instances, as in the Southwest, the measure moves the plant closer to the source of fuel so that the transportation cost of moving fuel is reduced.

While the control measure could apply to other industries as well, the number of attractive applications is probably limited by the added transportation costs for employees, raw materials, and plant output. Consequently, this measure has not been used extensively outside of the power industry.

b. Effectiveness of the Control Measure in Current Applications. Experience in the current application of this measure is not adequate to enable an evaluation of its effectiveness. It is emphasized that the implementation of this measure is not primarily for the purpose of emission reduction, but rather spatial redistribution and better use of atmospheric assimilative capacity. However, NSPS may also cause lower emissions from the replacement source.

3. Implementation

a. Procedures. Because this control measure is primarily a power industry measure, it is most easily implemented by incorporation into the growth plans of this industry. To a large degree, this has already taken place. Siting of power plants is a well-studied and much-discussed subject. Air quality impact statements are now mandatory for virtually all building permit applications for new power generating facilities.

Although there is considerable authority and practice in the regulation of new source admission within a controlled area, the relocation or removal of an existing source is not clearly defined as a possible control measure. Air pollution statutes in some jurisdictions authorize the control board to issue abatement orders which could result in court injunctions. These actions, however, have been used to force compliance with emission standards by application of accepted pollution control devices. Sources may be relocated indirectly by excluding specific source types from certain areas or by setting emission limits so low that they are unattainable.

Transfer of emission source location probably will come about as obsolete or uneconomical facilities are replaced. While the permit and review procedures for new and modified sources could serve as a mechanism for forcing transfer of emission sources through disapproval of the request for permission for construction or modification, special legal provisions should be established for power plant siting.

Some States, e.g., Ohio and Maryland, have enacted power plant siting legislation. A description of the Ohio legislation is presented, not as an example to be followed, but as a description of one State's approach. Other legislation, such as Maryland's, should be studied prior to developing such a system in States where none currently exist. Ohio has enacted power plant siting legislation that can serve as a model. The Ohio law established a Power Siting Commission composed of the Chairman of the Public Utilities Commission, the Director of Environmental Protection, the Director of Health, the Director of Development, and a public member, an engineer to be appointed by the Governor.

Prior to construction of a major facility, defined as one having a design or actual capacity of 50 MW or more, a certificate must be obtained from the Power Siting Commission. Certificates are obtained by filing an application containing the following information:

- Description and location of the facility,
- Summary of any studies of the environmental impact of the facility;
- Need for the facility,
- Reasons why the proposed location is best suited for the facility,
- How the facility fits into the applicant's 10-year forecast of loads, resources, and prospective sites, and
- Other information considered relevant by the applicant or the Commission.

The application, which must be filed not less than 2 years, nor more than 5 years prior to planned construction, is subject to public hearing within 60 to 90 days of receipt. Following the public hearing, the Power Siting Commission grants or denies the certificate after evaluating the effect on the environment using its own adopted rules and criteria. One of the criteria is that the proposed facility represents the minimum adverse environmental impact, considering the state of available technology and the nature and economics of the various alternatives.

The certificate is conditional upon the facility being in compliance with the applicable regulations governing air quality. The certificate applies to the initial 2 years of operation during which time the facility is subject to the enforcement and monitoring powers of the Director of Environmental Protection. If it is determined during the initial period that the facility is unable to operate within compliance of air quality laws and regulations, a conditional permit to operate may be issued.

Lead times for power plant construction now exceeds 10 years (ref. 52) so that the measure, implemented in this manner, demands foresight in planning in order to achieve maximum effectiveness.

b. Conditions of Applicability. This control measure is highly specialized in that the specific criteria of applicability vary from one industry to another. The relocation should not result in costs appreciably more than operation at the original site plus the cost of improved control equipment required to equivilantly reduce emissions. Capital costs, other than those involved with land acquisition, should be essentially the same regardless of the actual new plant location. If the relocation makes the plant output less expensive, no further justification is required. Such an ideal condition does not normally exist except in the power generating industry.

For electric power generation, certain relocations can make the output cheaper, such as when the power plant is relocated near the mouth of a coal mine. Coal shipping and ash disposal costs are greatly reduced and electric power transmission costs are not greatly increased once the power lines are installed.

Power plants do not have to be relocated to remote land areas. Alternatives are possible, including offshore sites. Offshore sites are attractive for both fossil fuel and nuclear fueled power plants (refs. 53, 54). This form of relocation, while limited primarily to coastal areas (rivers, inland lakes, or bays might also be suitable for certain inland sites), seems likely to be a significant form of this control measure in the future as land sites everywhere become less available.

Relocation to remote land sites is more and more being viewed as an inadequate, inappropriate shift of air pollution burden. Somewhat more pallatable is the offshore site but even here EIS's will be carefully reviewed and, most likely, excessive emissions (non-state-of-the-art) will be disapproved regardless of location.

The previously cited examples of relocation involve transfer of the site outside the area that might be included in an AQMA. The measure also has applicability to relocation of sources within an AQMA to clean up "hot spots" or prevent undue clustering that could result in "hot spots". In these cases, the air quality situation must be analyzed to ensure the ability of the area in which relocation will take place to assimilate the increased emissions.

c. Interactions With Other Control Measures. Transfer of emission source location occurs in the course of implementing other control measures and consequently can become part of them. For example, if a community adopts district heating as a control measure, the net effect is to relocate a multitude of individual space heating sources into one centralized source. This combination of sources is therefore a relocation as well. Or, when an industry decides to upgrade an existing operation, it is often advantageous to move to a new site as part of the plan.

In conjunction with an emission allocation plan, relocation may be one of the measures used to reduce total emissions in a problem subarea.

d. Potential Conflicts With Other Community Development Plans and Potential Negative Environmental Effects. The major shortcoming of this control measure is that of itself it does not permanently reduce air pollution emissions within the AQMA unless the new site is outside the AQMA boundaries. It can, however, result in maximum utilization of the assimilative capacity of the atmosphere by spatial redistribution of emissions. In such a case, however, the analysis must consider the impact of relocation on the new area. Determination must be made of the impact of this move on the air quality in the new area and whether such action would require designation as an AQMA and preparation of an AQMP. Only when coupled with other control measures will a net global gain in air quality result.

e. Practical Limitations

1) Social acceptability. Public acceptability of this strategy is marginal. Small minority groups can block or slow down proposed relocations and are doing so with increasing frequency. The EIS's accompanying applications for building permits are now being regularly challenged. EPA's acceptance of certain EIS's is also being challenged in the courts.

These objections apply to a lesser extent to offshore relocations but this concept is still new and untried so that significant opposition has not yet had a chance to coalesce. As portent of things to come, the Florida Audubon Society and the Natural Resources Defense Council are already asking for AEC rulings that could halt the New Jersey floating nuclear plant program.

2) Economic feasibility. Economic feasibility is a prerequisite for any serious control measure, including transfer of emission source location. Both land sites and offshore sites possess sufficient advantages for power plant relocation to be economically attractive. When moved nearer their sources of fuel, land sited power plants become less expensive to operate. Coal becomes cheaper because of reduced transportation costs; ash disposal is simplified and less expensive. Offshore sites have obvious cooling advantages in addition to safety, esthetic, and environmental advantages.

4. Evaluation of Control Measure Effectiveness

a. Ability of Control Measure to Maintain Standards. This control measure is limited in both effectiveness and applicability. One limitation arises from the long lead time required for implementation. A relocation of any type requires advance planning. In the case of power plants, the required lead time is now approaching 14 years, which is beyond the time frame covered by the AQMP. Nuclear power plants designed to be on stream by 1985 must already be well along in their site search in 1974.

b. Relative Efficiency When Compared to Other Measures. The efficiency with which this control measure operates depends on whose viewpoint is considered. The resident of downtown Los Angeles will find the measure very efficient in reducing his local power plant emissions. For the Four Corners resident, however, it is undesirable. This conflict of interests will limit the use of this control measure.

Offshore applications, particularly on the East Coast where prevailing winds sweep emissions out to sea, have the advantage of not grossly disadvantaging local citizenry in the vicinity of the relocated plant. As the international aspects of air pollution become more important, the import of emissions on Europe may effect the decision to construct an offshore plant.

H. INDIRECT SOURCE REVIEW

1. Definition of Control Measure

Indirect source review, in contract with most of the other maintenance control measures, is an integral, not an optional, part of every AQMP.

The types of new or modified sources that are to be reviewed for approval under this measure are cited in the regulation for maintenance of national standards, 40 CFR 52.22. The sources subject to review include, but are not limited to, the following:

- Highways and roads;
- Parking facilities;
- Retail, commercial, and industrial facilities;
- Recreation, amusement, sports, and entertainment facilities;
- Airports;
- Office and government buildings;
- Apartment and condominium buildings;
- Education facilities.

The above sources include most public and large commercial building projects.

The review procedure is limited, however, to developments above certain sizes, which are also stated in regulation 40 CFR 52.22 (b)(2). These size thresholds are specified in terms of daily traffic volumes for highways, annual aircraft operations for airports, and number of parking spaces for most other facilities. Indirect sources smaller than the threshold sizes are assumed to be evaluated and controlled as part of overall growth by other maintenance strategies.

The indirect source review procedures apply only to the automobile-related pollutants. The intent of this review procedure is to ensure good traffic design so that motor vehicle emissions in the vicinity of the indirect source are minimized. With few exceptions, the review should not result in a limitation on the size of the facility or influence its location.

Emission reductions are achieved through disapproval of deficient initial development plans, by requiring that modifications be made to the internal or access traffic handling facilities to improve projected traffic flow. The reviewing agency is not obligated to recommend the design modifications or improvements that should be made.

2. Historical Review of the Measure

a. Current Application. The concept of a systematic procedure for the review of proposed new indirect sources was first presented by EPA in the April 18, 1973, proposed guidelines to the States for preparation of approvable indirect source review measures (ref. 55). Final guidelines were promulgated on June 18, 1973 (ref. 56), and the States were given until August 15, 1973, to submit procedures in accordance with the guidelines for approval. No States were able to respond within this strenuous time frame, and only eight States and territories submitted procedures prior to the proposal of Federal regulations for indirect source review.* Since the public did not have adequate opportunity to comment on these eight plans, no State-submitted procedures could be approved.

Subsequently, the Administrator proposed Federal regulations for review of indirect sources on October 30, 1973 (ref. 57), to be applicable in the States that submitted nothing or whose plans could not be approved. The final regulations were promulgated on February 25, 1974 (ref. 58), but are to be applicable to indirect sources that start construction after December 31, 1974. These regulations are currently undergoing study and will be revised in the near future. Therefore, this administrative review procedure has no past history of employment that can be cited as a case study.

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*Alabama, Florida, Guam, Puerto Rico, Maine, New York, Oregon, and Washington.

Of the first eight plans submitted, only the Florida and Guam plans were fully approved at the time that the Federal regulations were promulgated. The Florida system for review and approval/disapproval of application to construct an indirect source was implemented as of December 15, 1973. Procedures were integrated into the existing permit system of the Florida Department of Pollution Control, and specially designed application forms (with instructions for completion) are currently used for two source categories: highway projects and nonhighway projects.

At the onset of this program, State personnel conducted instructional seminars in several areas to acquaint developers with the review procedure and the regulatory requirements. Additionally, the agency has prepared checklists for use by its field office personnel in reviewing applications in an effort to ensure uniform processing. In the first 2 months of implementation, the agency received approximately 25 permit applications dealing with indirect sources. Of these, the 12 that completed review were all approved as submitted.

b. Effectiveness of the Measure in Current Applications. This control measure does not have a record of past application.

3. Implementation

a. Procedure. The review procedure must be established and operated, at a minimum, in accordance with the general guidelines published on June 18, 1973, and under one of two possible sets of more detailed procedures:

1) Those described in an approved plan for review submitted by a State or

2) Those promulgated in 40 CFR 52.22 on February 25, 1974, to be implemented by EPA or an agency to which it has delegated the responsibility for conducting indirect source review. Since it is anticipated that the latter set of procedures will be more widely used, it is briefly described below. It is expected that these regulations may undergo revision.

The owner or operator of any proposed new indirect source subject to the regulations (see table II-7) must submit an application for approval to EPA or its designated agency prior to construction, by a

Table II-7. Indirect sources requiring approval

Location	Sources	Minimum size for review of impact of carbon monoxide air quality standards	Minimum size for review of impact on photochemical oxidant and nitrogen oxides air quality standards
Urban area (SMSA)	New roads and highways	20,000 vehicles per day (average)	50,000 vehicles per day (average)
	Modified roads and highways	10,000 vehicles per day over existing traffic (average)	25,000 vehicles per day over existing traffic (average)
	New airports	50,000 operations or 1.6 million passengers per year	50,000 operations or 1.6 million passengers per year
	Modified airports	50,000 operations per year increase over existing level, or increase of 1.6 million passengers per year	50,000 operations per year increase over existing level, or increase of 1.6 million passengers per year
	Other indirect sources, new	Parking for 1,000 cars or more	No analysis required
	Other indirect sources, modified	Parking for 500 cars or more over existing number	No analysis required
Nonurban area	Airports	Same as in urban areas	Same as in urban areas
	Other indirect sources, new	Parking for 2,000 cars of more	No analysis required
	Other indirect sources, modified	Parking for 1,000 cars or more over existing number	No analysis required

Source: 40 CFR 52.22 (b) (2), (February 25, 1974).

means prescribed by the Administrator. Information that must be included in or attached to the application is listed in table II-8; other information more specific to the type of facility may also be requested at the time of application. It is anticipated that, when the specifics of the review procedure are established, the list of required information, as shown in table II-8, will be expanded. For example, the design capacity of proposed highway sections will probably be required data.

According to the regulations, the reviewing agency must then fulfill the following:

1) Notify the applicant within 20 days of any deficiency in the information submitted;

2) Make a preliminary determination within 30 days whether the indirect source should be approved, conditionally approved, or disapproved;

3) Make a copy of information submitted and the agency's evaluation available for public inspection;

4) Notify the public and specified cognizant agencies of the opportunity for written comment within an additional 30-day period;

5) Make a final determination after considering the comments received; and

6) Notify the applicant in writing of the approval, conditional approval, or disapproval, with the reasons for the decision stated.

Determination of approvability is to be based on:

1) No interference with the applicable control strategy, if the source is to be located in an AQCR with a transportation control plan;

2) No violation of the carbon monoxide NAAQS (also the photochemical oxidant and nitrogen dioxide NAAQS for proposed major highways and airports), or no delay in attainment of the applicable standards if the date specified for attainment has not been reached. Specific procedures to be used in these determinations are delineated in vol. 9, guideline series, Evaluating Indirect Sources.

Further description of the review process may be found by referring directly to the regulation, 40 CFR 52.22. The minimum procedures for implementing this control measure are prescribed by regulation. There-

Table II-8. Required information for indirect source review

Indirect source type	Required information
All except highways	1. Name and address of applicant.
	2. Map showing location of the site.
	3. Description of proposed use, hours of operation, types of activities.
	4. Site plan showing buildings, parking areas, and points of auto ingress and egress.
	5. Identification of access roads and intersections.
	6. Estimate of present average daily traffic volumes (ADT), peaking characteristics, and levels of service on access roads and intersections.
	7. Estimate of average daily vehicle trips and peaking characteristics associated with the source (for its first full year of operation).
	8. Estimate of maximum number of vehicle trips within 1-hour and 8-hour periods.
	9. Estimate of ADT, peaking characteristics, and levels of service on access roads and intersections after source is operational.
	10. Availability of existing and projected mass transit service at the site.
	11. Any additional information necessary to determine air quality impact, including measured air quality data prior to construction.
Airports	In addition to the above,
	1. Estimate of average and maximum aircraft operations per day by aircraft type for first, fifth, and tenth year of operation.
	2. Description of other development expected to occur within three miles of airport.
	3. Expected passenger loadings.
Highway sections	1. Average and maximum traffic volumes for 1, 8, and 24-hour periods within 10 years of completion.
	2. Estimate of vehicle speeds for average and maximum traffic volumes.
	3. Maps showing location of the highway section.
	4. Description of general features of the highway section and right of way.
	5. A copy of any environmental impact statement prepared for the highway section.

Source: 40 CFR 52.22 (b) (3), (February 25, 1974).

fore, development of most procedures by the designated agency is not necessary. A major procedure to be formulated is that of coordination between the agency performing indirect source review and the agency responsible for carrying out the AQMP.

b. Conditions of Applicability. This control measure is a part of every AQMP, regardless of whether the plan is needed for control of any of the "automotive" pollutants. Thus, a discussion of conditions under which this review procedure could be applied effectively is not relevant.

c. Interaction with Other Measures. In the preamble to the June 18, 1973, promulgation, the Administrator acknowledged that indirect source review, while "a necessary addition" to an overall strategy for ensuring maintenance, could be considered only an additional tactic in such strategy, "because source-by-source analysis is not an adequate means of evaluating, on a regional scale, the air quality impact of growth and development...". Its primary purpose was stated to be to ensure "that the national standards will not be violated in the vicinity of a major new facility".

However, its role may be extended beyond that if it is used to provide a source-by-source check on the consistency of major proposed public and commercial projects with a regional land-use plan that has previously been demonstrated to be capable of maintaining air quality standards. In this capacity, indirect source review would serve as an enforcement mechanism in conjunction with a prior planning process.

The authority for this extension of the role of indirect source review is included in the provision that a proposed indirect source can only be approved if it "will not cause a violation of the control strategy of any applicable state implementation plan". Applicable portions of the land-use plan would need to be adopted as part of the maintenance plan. This combination of measures would not provide a means of correction if violations of the standard occur after the indirect source has been approved and constructed.

Indirect source review could be used in a similar manner in conjunction with a transportation control strategy to assist in its implementation.

The relationship between the indirect source review procedure and an EIS as required by the National Environmental Policy Act should also be noted. An EIS would not be required of all facilities qualifying as indirect sources, but would in general provide a more detailed analysis of air quality impact if it is conducted. Section 52.22 specifically states that any EIS for the source should accompany the application, and that information included in the EIS need not be provided separately in the application. This implies that, if judged to adequately answer all the points in the review process, the EIS evaluation may replace the standard analysis. However, the reviewing agency must still follow the six-step approval/disapproval procedure outlined above. This is particularly important because the EIS is only one factor in deciding whether a proposed project should be controlled, and air quality considerations may not dictate the final decision.

d. Potential Conflicts With Community Development Plans. The indirect source review could have the effect of limiting the size and/or density of commercial and municipal developments that are reached primarily by automobile. This could, in turn, result in a greater dispersion of trip-generation points and more and longer trips. In contrast, many area development plans favor clustering of these developments to encourage multiple-purpose trips and to enhance the feasibility of mass transit systems. To the extent that staged development of these traffic centers precludes the large-scale use of mass transit during intermediate stages of development, the indirect source review procedure may act to discourage plans that might be beneficial on a regional scale or on a long-range basis.

This potential conflict emphasizes the desirability of performing the review within the context of insuring compatibility of individual facilities with an areawide plan that has been found consistent with air quality maintenance. With a higher degree of planning and coordination for proposed cluster developments, any dispersive impact resulting from this review can be minimized.

e. Practical Limitations.

1) Social acceptability. Because the review procedure has primary involvement only by the developer and the reviewing agency, general public awareness of this control measure will probably be quite

limited. The review process does provide for comments by the public, so it offers a channel for participation for those who feel that they would be strongly affected by the proposed indirect source or by the results of the review.

Although the primary intent of this control measure is to minimize air pollution emissions through better traffic engineering design, it appears that the secondary benefit of reduced traffic congestion would have a favorable impact on most persons. Any increased on-site costs of the improved traffic flow would probably be borne indirectly by users of the facility, the same persons who would benefit most. Modifications to access roads or added signalization, on the other hand, would usually be financed through general tax funds.

Most criticism of the review process prior to promulgation of the Federal regulation was voiced by developers. Their comments are summarized in the preamble to the final promulgation (ref. 57) and are considered in the final version of the regulation.

2) Economic feasibility. The costs arising from actions taken to obtain approval under the indirect source review process appear to be quite minimal. Any additional cost to the developer to optimize the traffic and parking facilities, sufficient to reduce the impact of the source upon air quality, may not represent a true air pollution control cost. A direct benefit to the patrons of the source may result in the form of both time and fuel savings.

Data necessary to determine the air quality impact of the indirect source, as described in table II-7, should be readily available to the developer. Therefore, the added cost of submitting such data to the reviewing agency normally should not impose any significant financial burden upon the developer. Possible exceptions would be in cases where the applicant either is required to obtain and submit measured air quality data at the proposed site or chooses to perform atmospheric dispersion model analyses prior to submitting the application.

4. Evaluation of Control Measure Effectiveness

a. Ability of Strategy to Maintain Standards. The effectiveness of indirect source review in maintaining NAAQS's should be judged on two different scales of analysis--a microscale and a AQMA scale. If this separation is accepted as a valid, logical distinction, effectiveness can be adequately discussed in solely qualitative terms without resorting to any quantitative methodology.

On a microscale, indirect source review alone should be effective in preventing the carbon monoxide standards from being exceeded as a result of motor vehicle emissions. This comprehensive control is limited only by the ability of the review procedure to accurately predict traffic volumes, traffic behavioral characteristics, and resulting maximum CO concentrations associated with the proposed indirect source.

With a few modifications, the procedure as it exists now could also be used to effectively control maximum short-term concentrations of hydrocarbons and nitrogen oxides on a microscale, if this were of value. However, both of these are reactive pollutant groups, and the short-term "standard" for hydrocarbons is only for use as a guide to levels consistent with maintenance of the oxidant standard. Therefore, limitations on HC and NO_x levels in the immediate vicinity of their emission would probably not have any quantifiable effect on maintenance of NAAQS's within an AQMA. Only the aggregate effect of emission reductions at many different locations during time periods prior to the measurement of peak ambient concentrations can be expected to reduce these maximum concentrations.

On the AQMA scale, the indirect source review process is not capable of significantly controlling total emissions of automotive pollutants. Its resultant effect on CO levels is best described as peak-shaving; i.e., it acts to limit concentrations in potential "hot spots", or isolated areas of high traffic density, but probably has no measurable impact on CO emissions or ambient concentrations in most parts of the AQMA.

The major shortcoming of the review procedure in maintaining the CO standards on an AQMA scale is that it cannot consider traffic increases resulting from an area's population growth that may occur at indirect sources that were in existence prior to 1975. For example, a new residential area may generate sufficient traffic on an existing highway connecting it to a large employment center to result in the CO standards being exceeded. However, unless the highway is modified, it would not be subject to the indirect source review procedure.

Only two types of indirect sources are to be reviewed for their impact on regional oxidant and nitrogen oxides concentrations: airports (50,000 or more operations/year or 1,600,000 passengers/year) and major highways (more than 50,000 vehicles/day on an existing one). EPA-recommended review procedures are forthcoming, so it is not yet possible to determine what effect this review will have on maintenance for these two pollutants.

b. Relative Efficiency When Compared to Other Measures. By the very nature of its evolution, the indirect source review procedure is intended to be an important part of air quality maintenance within an AQMA. It serves as a check for air quality maintenance on a very localized scale. As one component of the AQMP, it may also be structured to serve as an implementation or enforcement mechanism to ensure that individual projects are consistent with some broader maintenance or development program that has been established in the plan.

The review procedure does not offer a prior constraint on planning because of its postplanning, preconstruction position. Moreover, the procedure is not capable of evaluating air quality impacts of proposed or projected growth on a regional scale. Therefore, it appears that indirect source review is a necessary, but not sufficient, measure in areas where an AQMP is needed. In developing an AQMP, no credit should be given for pollutant emission or ambient concentration reductions due to the existence of the indirect source controls.

I. ENVIRONMENTAL IMPACT STATEMENTS (EIS's)

1. Definition of Control Measure

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires all Federal agencies to submit an EIS to the Council on Environmental Quality (CEQ) prior to taking major actions that may significantly affect the human environment. Furthermore, the act requires that an EIS be prepared in consultation with those Federal agencies that have jurisdiction by law or special expertise with respect to any environmental impact involved. In general, the provisions of NEPA apply to projects that are administered or funded by the Federal Government; an EIS must accompany a proposal for action through the existing agency review process.

Although NEPA does not explicitly state that a project's effect on air quality is to be discussed in an EIS, both CEQ guidelines (ref. 59) and agency regulations for the preparation of EIS's stipulate that air quality impacts are to be considered. Probably the most significant air pollution emission sources requiring EIS's are proposed Federal or federally assisted highways and airports, and power plants.

In addition to Federal environmental legislation, 17 States and the Commonwealth of Puerto Rico have legislatively adopted or administratively promulgated policies and provisions similar to NEPA (ref. 60). While most of the jurisdictions make use of an EIS in one way or another, the applicability and scope of the EIS requirement varies.

2. Historical Review of the Control Measure

a. Current Application. From January 1, 1970, the date NEPA became effective, through December 31, 1973, 4,783 EIS's were filed with CEQ. Of these, 2,012 were for highways and roads, 371 were for airports, and 44 were for power plants (ref. 61).

Guidelines for the preparation of EIS's issued by CEQ in 1971 directed each Federal agency to establish its own formal procedures for complying with NEPA. These guidelines and, in turn, Federal agency regulations have had to be revised periodically to implement various Federal court decisions relating to NEPA. Almost all of the approximately 220 NEPA cases reported between January 1970 and September 1973 focused on some aspect of the EIS (ref. 62). The courts generally have assumed responsibility for interpreting and enforcing procedures set forth in sec. 102(2)(C), including: 1) its applicability (i.e., whether an action is major, Federal, and significantly affects the environment and therefore requires an EIS); 2) the scope and depth of information necessary in an EIS, including the extent to which alternatives must be discussed; and 3) how information in an EIS must be considered in making a final decision.

Some courts have specifically discussed the need for air quality assessment in an EIS. For example, in the case of Keith vs. Volpe, July 7, 1972, a California District Court halted work on the 17-mile Century Freeway (I-105) in Los Angeles County until an EIS was prepared and considered in accordance with the requirements of NEPA and the California Environmental Quality Act. Among other things, the court declared that the EIS should examine, with as much precision as possible, the impact of the proposed freeway on air quality in the Los Angeles basin. In evaluating the air quality impact, the court said the EIS should consider the effect of wind and weather on the dispersal of pollutants as well as the effect of other sources of pollution and the extent to which the freeway would draw more automobiles into the southern Los Angeles basin (ref. 63).

b. Effectiveness of the Measure in Current Applications. The sole purpose of an EIS is to alert decision makers and the general public to the environmental risks involved in major Federal actions. If the final EIS indicates that there are adverse environmental effects, including air quality impacts, associated with what is considered to be the best alternative action, decision makers must evaluate whether the adverse environmental effects outweigh the benefits of proceeding with the projects. NEPA, however, does not provide veto power over the decision that is finally made.

3. Implementation

a. Procedures. An EIS must include the following:

1) A detailed description of the proposed project, including information and technical data adequate to permit a careful assessment of the environmental impact.

2) Discussion of the probable impact on the environment.

3) Any adverse effects that cannot be avoided.

4) Alternatives to the proposed action that might avoid some or all of the adverse environmental impacts, including an analysis of the cost and environmental impacts of each alternative.

5) An assessment of the cumulative, long-term use of the environment versus the environment's long-term productivity.

6) Any irreversible or irretrievable commitments of resources that might result from the action that would curtail beneficial use of the environment.

The preparation of an EIS involves a two-step process. First, a draft statement is prepared that draws together all the data needed to inform Federal officials and the general public about the environmental effects of a proposed project and of possible alternative actions. The draft statement is circulated for comment to Federal, State, and local environmental agencies and to the general public, who have a minimum of 45 days to review and comment on the draft statement.

After all comments made during the review process (and at the public hearing if one is held) are received, the EIS is prepared in final form. The final EIS must incorporate all comments and objectives raised on the draft and indicate how significant issues have been resolved. Once a final EIS is completed, it must be filed with CEQ and made available to the public and those agencies that reviewed the draft statement.

Section 309 of the Clean Air Act, as amended, requires that the Administrator of EPA comment in writing on the possible environmental impacts (i.e., air, noise, water, solid waste) of all proposed Federal actions to which sec. 102(2)(C) of NEPA applies. After his review, the Administrator has to make his comments public. If he finds a proposal environmentally unsatisfactory, he has to publish this finding and refer the matter to CEQ (ref. 64).

Except for highly controversial projects, most highway and airport EIS's are reviewed by EPA Regional Offices. The most important consideration in any EPA air quality review is whether or not the project adversely affects the attainment or maintenance of the NAAQS. Such a determination depends, to a great extent, upon the adequacy of the EIS and the ability of the reviewer to assess the significance of the material presented.

EPA Order 1640.1, Review of Federal Action Impacting the Environment, established separate rating systems for project impact and EIS adequacy. These systems, which are used in reviewing draft EIS's, are described in table II-9.

b. Applicability. According to CEQ guidelines, major Federal actions include but are not limited to:

1) Recommendations or favorable reports relating to legislation and appropriations;

2) New and continuing projects and program activities: directly undertaken by Federal agencies; supported in whole or in part through Federal contracts, grants, subsidies, loans, or other forms of funding assistance; involving a Federal lease, permit, license, certificate or other entitlement for use; the making, modification, or establishment of regulations, rules, procedures, and policy (ref. 59).

Table II-9. EPA rating systems for project impact and EIS adequacy

Rating area	Rating	Definition
Environmental Impact of the Action	LO (Lack of Objections)	EPA has no objections to the proposed action as described in the draft EIS; or suggests only minor changes in the proposed action.
	ER (Environmental Reservations)	EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating Federal agency to reassess these aspects.
	EU (Environmentally Unsatisfactory)	EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards that might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).
Adequacy of the EIS	Category 1 (Adequate)	The draft EIS adequately sets forth the environmental impact of the proposed project or action as well as alternatives reasonably available to the project or action.
	Category 2 (Insufficient Information)	EPA believes that the draft EIS does not contain sufficient information to assess fully the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft statement.
	Category 3 (Inadequate)	EPA believes that the draft EIS does not adequately assess the environmental impact of the proposed project or action, or that the EIS inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the EIS. If a draft EIS is assigned a Category 3, no rating will be made of the project or action, since a basis does not generally exist on which to make such a determination.

Each Federal agency is responsible for identifying whether the actions it seeks to undertake are major and significantly affect the environment. CEQ guidelines state that the words "major" and "significantly" are intended to imply thresholds of importance and impact that must be met before a statement is required. CEQ has directed that each agency review the typical classes of actions it undertakes and develop specific criteria and methods for identifying actions likely to require EIS's.

As noted earlier, the applicability of the EIS requirements at the State level varies. Most State provisions follow NEPA's lead and limit applicability to "agencies of the State." Among the exceptions are the California Environmental Quality Act, which outlines specific responsibilities for local governments, and Washington's Environmental Policy Act, which applies to all branches of State government, including State agencies, municipal and public corporations, and counties. North Carolina authorizes local governments to require an EIS from any public or private developer of a "major development project" (ref. 65).

In defining major, environmentally significant actions, State EIS provisions generally parallel Federal requirements. However, there are exceptions. For example, the courts have extended California's EIS requirements to private activities requiring public permission; Indiana's law explicitly excludes licensing activities; and North Carolina limits its EIS requirements to "actions involving expenditures of public moneys for projects and programs significantly affecting the quality of the environment."

c. Interaction with Other Measures. The EIS interacts with three other control measures in maintaining air quality standards: regional development planning, indirect source review, and control of construction activities.

While regional development planning can provide a general guide to the siting and location of various types of development, it cannot predict if air quality standards will be exceeded by an individual project. In addition to assessing whether or not a proposed project is compatible with an adopted regional plan, an EIS can identify localized air pollution problems associated with a project that could interfere with the maintenance of air quality standards.

If an EIS is prepared for an action subject to indirect source review, it should accompany the application for approval through the review process and may substitute for the standard analysis outlined in 40 CFR 52.22.

An EIS is one of the few measures that assesses impacts on air quality during the construction phase of a project; in addition, an agency preparing an EIS must indicate what steps will be taken during construction to minimize those impacts.

d. Potential Conflicts with Community Development Plans. CEQ guidelines require that an EIS discuss the relationship of a proposed project to approved or proposed Federal, State and local land-use plans, policies, and controls for the project area. If a conflict or inconsistency exists, the EIS should describe the extent to which the project has been reconciled with the plan. If full reconcilation has not been achieved, the EIS must discuss why the sponsoring agency has decided to proceed with the project.

e. Practical Limitations.

1) Social acceptability. Public participation as early as possible in the EIS process is encouraged by CEQ. Some agencies have actually sponsored extensive community participation programs throughout the environmental assessment phase of a project in order to ensure that major community concerns are addressed in an EIS. As a minimum, a draft EIS must be made available to the public, which has at least 45 days to comment. Responses to substantive comments received on a draft statement must be incorporated into the final EIS. In general, public reaction to the EIS process appears to depend upon whether an individual approves or disapproves of a project. Those who approve often see the EIS process as an unnecessary delay, while those who disapprove welcome the EIS as a means of alerting decision makers to the specific social, economic, and environmental problems associated with a proposed project.

2) Economic feasibility. The preparation of an EIS does not represent a true air pollution control cost since air quality impact is only one of many environmental aspects examined in an EIS. The detail provided in an EIS, and hence the cost of preparation, should be commensurate with the extent and expected impact of the proposed project and with the amount of information required at a particular decisionmaking level. Generally, the sponsoring Federal agency assumes

the cost of an EIS for a project under its jurisdiction.

4. Evaluation of Control Measure

a. Ability of Measure to Maintain Standards. The EIS alone would not be effective in maintaining air quality standards. First, the EIS requirement is not comprehensive enough, particularly in those States that have not enacted "little NEPA's." Because of the limited applicability of NEPA, major air pollution sources such as large-scale, privately funded industrial, commercial, and recreational facilities are not subject to the EIS requirement.

Second, air quality considerations do not necessarily dictate the final decision on a project. Although decision makers are required to consider the environmental impacts of a proposed action--including whether or not it is in conformance with a State's air pollution control implementation plan--they are permitted to balance these impacts against the project's economic and technical benefits before making a final decision.

It should be noted, however, that as Federal guidelines and regulations for the preparation of EIS's are refined over time and as coordination among agencies improves, mitigation of any serious environmental impacts associated with a project is likely to be accomplished early in the planning process.

b. Relative Efficiency Compared to Other Measures. An EIS air quality analysis relates the impact of proposed new emission sources to the applicable air quality standards; thus, it provides a direct check for maintenance of the standards. However, the review process does not apply to all new sources, nor even to entire source categories. Therefore, it is not a sufficient measure for maintenance by itself. It is difficult to assign an efficiency to the EIS when it is employed in conjunction with other measures, since its efficiency depends to a great extent on the scope of its applicability; i.e., whether a State has an environmental policy act in effect to supplement Federal environmental legislation.

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Chapter III: EMISSION CONTROL MEASURES

A. NEW SOURCE PERFORMANCE STANDARDS

1. Definition of Control Measure

This measure encompasses two distinct programs that have the common characteristic of requiring stringent controls on new sources: Federal New Source Performance Standards (NSPS), and State and local requirements for lower allowable emissions for new or modified sources than for existing ones.

a. Federal Programs. A New Source Performance Standard (NSPS) is defined in the Clean Air Act as "a standard for emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction) the Administrator determines has been adequately demonstrated (ref. 1). Responsibility for development, implementation, and enforcement of the Federally promulgated NSPS rests with EPA. Authority for implementation and enforcement may be delegated to the States upon submission and approval by the Administrator of adequate procedures for these purposes. NSPS are applicable only to new or modified sources in specific stationary source categories proposed and promulgated by EPA. The procedure requires testing of the source after startup to determine compliance.

The NSPS generally provide more restrictive controls than the SIP regulations for existing sources, thereby ensuring minimal impact from new sources in the specified categories. Another aspect of this measure's air quality maintenance action is the reduction in emissions that results from obsolete sources being modified or replaced by comparable new ones that are subject to the lower allowable emission rates of the NSPS. As more source categories are included under the provisions of the NSPS, this measure will increase in scope and effectiveness in minimizing emissions.

Upon promulgation, the emission limitations of the NSPS are mandatory on all subsequent new or modified sources. Therefore, this measure is present in all areas independent of AQMP provisions and should be considered as an integral component of all AQMP's.

While NSPS may be developed for hazardous air pollutants and designated pollutants, the discussion in this section is limited to the applicability of NSPS to the criteria pollutants. NSPS controls may be expressed as process weight, concentrations, or operating parameters.

b. State Programs. Under the Federal program, NSPS are adopted according to nationwide priority, which may not be the same as that required for any specific AQMA. Nothing in the Federal regulations precludes the States from prescribing lower allowable emissions limitations on new sources in categories not covered by Federal NSPS. This would permit the tailoring of a program specific to the AQMA. Should Federal NSPS be subsequently developed and promulgated, the State-developed emission limitations would continue to be applicable if they are at least as stringent as the NSPS. If the State-developed emission limitations are less stringent, the NSPS requirements would take precedence.

State regulations usually have provisions for review of new sources prior to construction, and call for disapproval if the applicable emission regulations or NAAQS would be violated. A State or local regulation with more stringent emission limitations on new or modified sources would be implemented through this review procedure. As with Federal NSPS, State-imposed emission limitations on new and modified sources are based on demonstrated best available control technology considered in the light of social and economic feasibility.

2. Historical Review of the Measure

As previously mentioned, most SIP's contain provisions for more stringent controls on new or modified sources than on sources in existence at the time the SIP's were prepared. Because it would be patently impossible to describe the history of State generated and implemented NSPS, discussion in this paragraph is limited to the Federal NSPS.

a. Current Application. The promulgation of NSPS serves as one regulatory path to ensure the application of best technology in the control of emissions from new and modified sources. NSPS are not intended to be the sole regulatory path for reducing emissions of these pollutants, but rather to be a control mechanism in the overall strategy of air pollution control and maintenance.

The Congress directed that the Administrator publish, within 90 days after enactment of the Clean Air Act amendments of 1970, a list of categories of stationary sources. This list, subject to periodic review, was to include a category of sources "if he determines it may contribute significantly to air pollution which causes or contributes to the endangerment of public health or welfare (ref. 1)." The initial listing of stationary sources for which NSPS were proposed in August 1971 and promulgated in December of the same year covered five source categories: fossil-fuel-fired steam generators, municipal incinerators, cement plants, nitric acid plants, and sulfuric acid plants. A second list proposed in June 1973 and promulgated in March 1974 covered asphalt concrete plants, petroleum refineries, petroleum storage, secondary lead smelters and refineries, secondary brass and bronze refining facilities, iron and steel mills, and sewage treatment plants. Table III-1 summarizes the source categories currently covered by NSPS. In addition, NSPS for primary copper, zinc, and lead smelters are nearing completion. These NSPS cover SO_2 emissions from all three primary smelters and particulates from zinc and lead.

b. Effectiveness of the Measure in Current Applications. Evaluation of the effectiveness of NSPS in current applications involves the evaluation of the impact of a single source within an area through individual source review. While such an evaluation may be possible, its accuracy is limited because in the current state-of-the-art, "analytical tools that can be used with confidence to predict the air quality impact of a single source are not now available (ref. 2)."

3. Implementation

Implementation of State NSPS is accomplished through the new and modified source review procedures specified in the SIP. The discussion that follows covers the implementation of Federally promulgated NSPS.

a. Procedures. NSPS are automatically implemented without action on the part of the States. The owner/operator of a facility falling within the purview of NSPS must provide EPA with:

- Notification of the anticipated date of initial startup.
- Notification of the actual date of startup.

Table III-1. Status of standards of performance for selected source categories (NSPS)

Source	Affected facility	Pollutant	Opacity Regulation	Control equipment expected to meet performance standard	Overall collection efficiency required, %	Status of performance standard
Steam generators	Coal- and oil-fired boilers	Particulates	✓	Precipitator (coal)	98	Promulgated 12/71
(> 250 million Btu/hr)	Coal- and oil-fired boilers	SO_x		Scrubber or low-S fuel	70-90	"
	Coal- , oil- , and gas-fired boilers	NO_x		Combustion modification	65-90	"
Municipal incinerators (> 50 tons per day)	Incinerator	Particulates	✓	Precipitator	95	"
Portland cement plants	Kiln, clinker cooler	Particulates	✓	Precipitator or fabric filter	99.3-99.7	"
Nitric acid plants	Process equipment	NO_x	✓	Catalytic decomposition	93	"
Sulfuric acid plants	Process equipment	SO_x		Dual absorption acid plant	96	"
		Acid mist	✓	Fiber mist eliminator	98.5	"
Asphalt concrete plants	Process equipment	Particulates	✓	Cyclone and fabric filter or venturi scrubber	99.7	Promulgated 3/8/74
Petroleum refineries	Process gas combustion	SO_x		H_2S scrubbing units	99+	"
	Catalytic regenerator	Particulates	✓	Precipitator	93	"
		CO		Waste heat boiler	99.5	"
Petroleum storage	Gasoline, crude oil, and distillate storage tanks > 65,000 gal capacity	Hydrocarbons		Conservation vent, floating roof, or vapor recovery systems	80	"
Secondary lead smelters and refineries	Blast and reverberatory furnaces	Particulates	✓	Fabric filter or high energy scrubber	97+	"
Secondary brass and bronze refining facilities	Reverberatory furnaces	Particulates	✓	Fabric filter	98.7	"
Iron and steel mills	Basic oxygen furnace	Particulates	✓	Furnace hooded to high energy scrubber or precipitator	99.8	"
Sewage treatment plants	Sludge incinerators	Particulates	✓	Venturi scrubber	99.6	"

Sources: Based on Table 1, in Gary D. McCutchen. New Source Performance Standards--Present and Future. Paper presented at the Fourth Annual Industrial Air Pollution Control Conference, Knoxville, Tenn., March 28-29, 1974.

U.S. Environmental Protection Agency, Office of Air Programs. Background Information for Proposed New Source Performance Standards: Steam Generators, Portland Cement Plants, Nitric Acid Plants, Sulfuric Acid Plants, Technical Report APTD-07-1, Research Triangle Park, N.C., August 1971.

U.S. Environmental Protection Agency, Office of Air Programs. Background Information for Proposed New Source Performance Standards: Asphalt Concrete Plants, Petroleum Refineries, Storage Vessels, Secondary Lead Smelters and Refiners, Brass or Bronze Ingot Production Plants, Iron and Steel Plants, Sewage Treatment Plants, Vol. 1, Main Text. Technical Report APTD-1352a, Research Triangle Park, N.C., June 1973.

In addition, the owner/operator shall provide EPA, within 60 days after achieving the maximum production rate but not later than 180 days after initial startup, reports of performance tests conducted in the manner and by the method prescribed in the NSPS regulations. A 10-day notice of the proposed performance tests is required to permit EPA an opportunity to observe such tests. In addition to the performance tests associated with startup, EPA under section 114 of the Clean Air Act can require such additional tests as are deemed necessary to ensure compliance with the NSPS.

Under provisions of section 111(d) of the Clean Air Act, States may develop and submit to EPA procedures for the implementation and enforcement of NSPS for new sources located in the State (except new sources owned or operated by the United States). If a State's procedure is found to be adequate, authority to implement and enforce NSPS can be delegated to the State.

Upon the publication of NSPS, States may adopt regulations that are equal to or more stringent as the NSPS. This revision to State regulations is accomplished through existing procedures within the State. Unless the States have been delegated procedures to implement and enforce NSPS, the owner/operator is still required to comply with the Federal requirement and submit reports to EPA, in addition to the requirements that may be imposed by the States. This course of action by the States is considered less desirable than the development of an EPA-approvable procedure for implementation and enforcement of NSPS and subsequent delegation of authority. The requirement for dual report submission may constitute a hardship on the owner/operator and may result in differing interpretation of regulations and test results.

Regardless of the methods by which NSPS are implemented, local review and enforcement are accomplished through the mechanisms established by the SIP. Requests for permission to construct a new source or modify an existing one are processed through the same system as sources not covered by NSPS. Surveillance and enforcement procedures are the same whether or not the source is covered by NSPS. In essence, NSPS simply supplant State regulatory requirements for selected sources unless existing State emission limitations are more stringent than NSPS.

b. Applicability. NSPS are applicable to any new stationary source, the construction or modification of which is commenced after the publication of the NSPS regulations. Promulgation of NSPS does not abrogate the requirements for the review of new and modified sources as required by 40 CFR 51.18. If the cognizant State or local agency determines that the construction or modification will interfere with the maintenance of a NAAQS, permit to construct or modify must be denied even if the construction or modification plans provide for the emission control required by NSPS.

Existing SIP requirements in some States may be more stringent than those imposed by NSPS. In these cases, the more stringent State requirements must be met by new and modified sources.

c. Interaction with Other Measures. Because NSPS are applicable to construction or modification of specific sources, they are implemented without specific interaction with other maintenance measures.

NSPS can, however, be used as the implementing mechanism for other control measures. For example, NSPS may be used to phase out inefficient domestic oil furnaces or unmonitored on-site incinerators by specifying emission limitations on new and replacement units. NSPS may also be used to implement the combination of emission source measures by requiring emission controls on new and modified sources that can only be met by consolidation of numerous small emittors into a larger source.

d. Potential Conflicts with Community Development Plans. NSPS will not result in conflicts with community development plans. NSPS are implemented after a decision has been made to construct a new source or modify an existing source. It must be assumed that the AQMP will contain provisions to ensure that such decisions are made within the context of the community development plan. Thus, NSPS can be considered to be not only consistent with such plans, but also complementary thereto. The application of NSPS to sources within an AQMA can result in overall emission reductions that would permit the growth envisioned in the community development plan.

e. Practical Limitations.

1) Social acceptability. No problems are envisioned with the social acceptability of NSPS. Most States currently specify more stringent controls for new and modified plants. This action has

generally been accepted. NSPS merely extends more stringent standards on new and modified plants to require the best available control technology. A public information program, especially for NSPS covering ubiquitous sources, should contribute to acceptance by the public by informing them of the need for and contribution that NSPS can make to their welfare through a cleaner environment. Public information programs are not uniquely applicable to NSPS, but are revelant to all maintenance measures.

2) Economic feasibility. Economic considerations play an important role in the development of NSPS. In the detailed study that precedes the promulgation of NSPS, control technologies are evaluated with respect to cost and effectiveness by analyses of field data obtained from well-controlled plants. Cost-effectiveness analysis, an integral part of the NSPS development, considers not only the direct costs of control equipment, but also the benefits that may occur from higher production efficiency and value of byproducts from the control system, taking into consideration the cost of achieving such reduction.

4. Evaluation of Control Measure

NSPS impact on air quality by controlling emissions from new and modified sources. New and modified sources are brought on stream to replace obsolete facilities or to provide additional production capacity to meet increased demands. The applicability of NSPS to construction and modification is shown schematically in figure III-1. The additional control potential of NSPS for all emissions, however, must consider other factors such as the portion of growth requirements that can be satisfied from present unused capacity and the obsolescence and replacement rates of existing facilities. Such a comparison can be expressed mathematically. The following equations can be used to determine the impact of NSPS on emission rates (ref. 3). The equation is not applicable when E_s is lower than E_n.

$$\text{Emission reduction by application of NSPS (tons)} = K(E_s - E_n)(B + C)$$

where K = Normal fractional utilization of existing capacity, assumed constant during time interval

E_s = Allowable emissions under SIP, tons per unit capacity

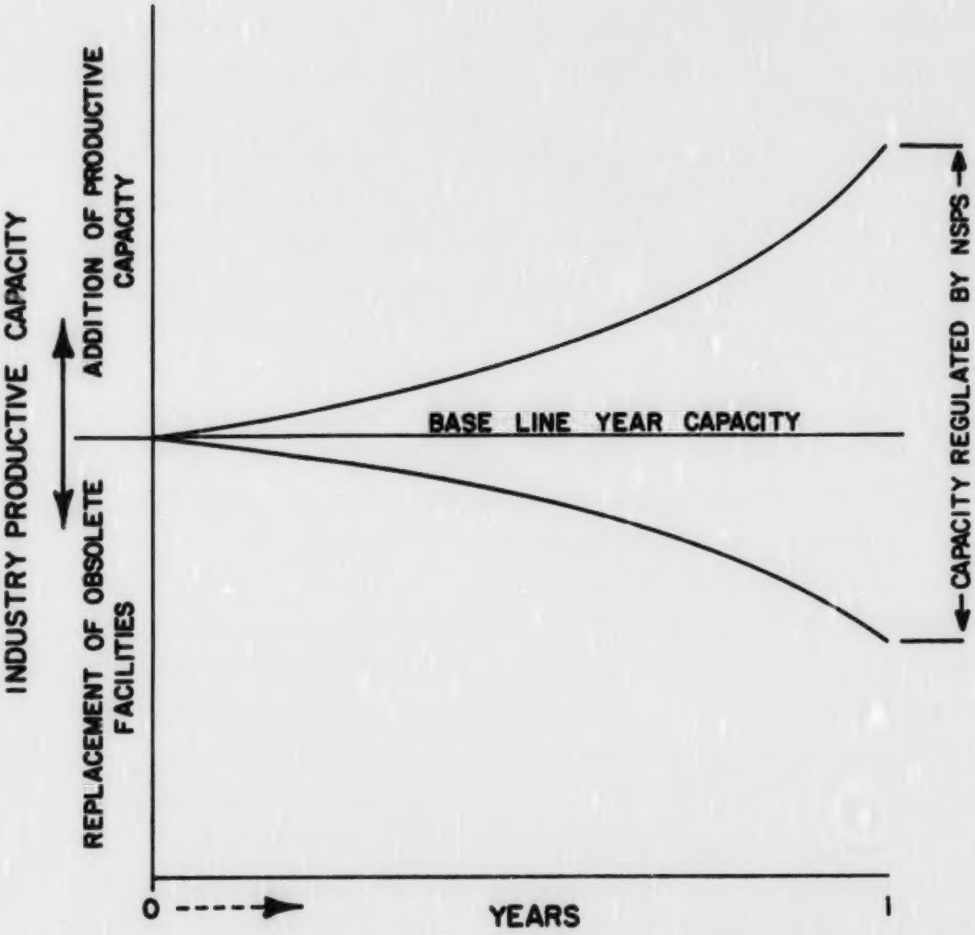
INDUSTRY PRODUCTIVE CAPACITY
ADDITION OF PRODUCTIVE CAPACITY
REPLACEMENT OF OBSOLETE FACILITIES
BASE LINE YEAR CAPACITY
CAPACITY REGULATED BY NSPS
0
YEARS
i

Figure III-1. Schematic representation showing applicability of NSPS to construction and modification.

E_n = Allowable emissions under NSPS, tons per unit capacity

B = Production capacity from construction or modification to replace obsolete plants

C = Production capacity from construction or modification to meet increased demands

where for compound growth, $B = A[(1 + P_b)^i - 1]$

$C = A[(1 + P_c)^i - 1]$

where for simple growth, $B = AiP_b$

$C = AiP_c$

A = 1975 capacity

P_b = Annual obsolescence rate

P_c = Annual growth rate

i = Elapsed time, years

For those sources not covered by NSPS, States have the option of imposing more stringent controls on new and modified sources than are currently prescribed in the SIP. In such a case, the methodology for evaluating the effectiveness of NSPS as described above is applicable. The term E_n is redefined as the allowable emissions in tons per unit capacity, under the more stringent SIP controls. In determining the appropriate E_n, States must balance the economic impacts of prescribing overly restrictive control with the current state-of-the-art of control technology.

B. REVISION OF EXISTING SIP CONTROL MEASURES

1. Definition of Measure

An early step in the development of the AQMP is the determination of whether more stringent emission limitations on existing sources would be adequate to maintain air quality. If more stringent emission limitations alone would be sufficient, an AQMP is not required. Amendment of pertinent existing State regulations and demonstration that the revised control measures would result in the maintenance of air quality is sufficient to satisfy the air quality maintenance requirements. Such limitations would be all that would be required in the AQMP.

Should more stringent controls not be technically or economically feasible and/or should such an analysis indicate that these measures would not, by themselves, provide the control required to maintain NAAQS during the period 1975 through 1985, a more comprehensive AQMP would be required. Revision of the existing SIP emission limitations then becomes one measure among many that should be considered in the development of an appropriate overall maintenance strategy. The extent to which such a measure could be implemented would depend on the existing level of control and the types of emission sources present in the area.

2. Historical Review of the Measure

a. Current Application. This measure has been applied in numerous States, in the development and revision of SIP control strategies or by EPA promulgation of standards for those AQCR's for which the SIP, as submitted by the State, was inadequate for the attainment and maintenance of NAAQS.

b. Effectiveness of the Measure in Current Applications. Evaluation of the effectiveness of this measure in current applications will have to wait until 1975 or 1977, the target dates for attainment of NAAQS. However, some estimate of further reduction in emissions can be obtained by examining the degree of control required to meet current emission regulations. For example, if control efficiencies in the range of 90-95 percent are currently required to achieve standards for suspended particulates, additional reduction of emissions could be achieved by requiring controls in the range of 96-98 percent. If required controls are already very stringent, for example, in the 96-99 percent range, then further reduction may be more difficult and expensive to achieve.

3. Implementation

a. Procedure. Procedures for revising SIP control requirements are described in the various SIP's. Under the assumption that emission reductions are not needed immediately to maintain standards, it may be appropriate to provide a period of 5 to 10 years for sources in compliance with existing regulations to come into compliance with the new, stricter regulations.

b. Conditions of Applicability. This maintenance measure is applicable to 1) sources currently under control but for which additional control is feasible, and 2) sources currently uncontrolled.

c. Interactions With Other Control Measures. Because this measure is applied to selected sources, it is implemented and enforced without specific interaction with other maintenance measures. For stationary sources, the emission controls specified by this measure are superseded for new and modified sources upon the promulgation of NSPS requiring more stringent control and, conversely, supersede NSPS control requirements that are less stringent.

d. Potential Conflicts With Community Development Plans. The imposition of more stringent SIP controls has the potential of conflicting with community development plans. For example, the imposition of more stringent SIP controls could curtail growth or even drive an industry out of an area, while community development objectives may include the encouragement of growth in the same industry.

e. Practical Limitations.

1) Social acceptability. The imposition of more stringent controls on sources currently under control will probably meet considerable opposition. Sources that have instituted control programs or have either installed or contracted for the installation of control equipment will most likely object to being given a "moving target" insofar as control requirements are concerned. Furthermore, industry can be expected to object to being required to spend funds for additional control when the expected reductions in emissions are to accommodate projected growth, especially if the growth represents competition.

Because the social acceptability of this measure is relatively low, its inclusion in the maintenance strategy should be carefully considered.

The imposition of controls on all new or modified that are more stringent than controls on existing sources can, however, be more easily achieved.

2) Economic feasibility. Economic feasibility of this control measure can be determined by an analysis of the impact on classes of sources. In general, the cost per unit reduction of emissions will be higher than the cost under the existing control requirements. However, these added costs do provide large percentage reductions in the remaining emissions since only a small increase in control efficiency, e.g., 98 to 99 percent, will cut remaining emissions drastically, (increasing from 98 to 99 percent represents a 50 percent reduction in emissions).

4. Evaluation of Control Measure

Potential emission reductions from this control measure can be evaluated by the following formula:

$$\text{Potential reduction} = (E_s - E_r)C$$

where E_s = Emission allowances under the existing control requirements

E_r = Emission allowances under the more stringent requirements

C = Source capacity affected by more stringent requirements during the time frame under consideration

These data should be readily available in the air pollution control agency having jurisdiction over the area in which the sources are located.

C. PHASEOUT OR PROHIBITION OF EMISSION SOURCES

1. Definition of Control Measure

Phaseout of emission sources is a measure whereby certain emission sources are eliminated by prohibiting their incorporation into new construction or by prohibiting operation of existing sources. Those sources already in use are not affected until obsolescence requires replacement or the prohibition date arrives, at which time they become subject to the provisions of this measure. Phaseout of existing emission sources can occur as the result of a business decision, as a result of mandatory prohibition by a specified date, or as a result of the imposition of stringent performance specifications on emission sources.

Outright prohibition of pollution sources is exemplified by rules 57 and 58 of the Los Angeles County Pollution Control District banning open firing of refuse and the use of single chamber incinerators.

To be successful, acceptable alternative equipment or services must be available for whatever is to be phased out. It is desirable that these alternatives be cost competitive in addition to offering reduced pollutant emissions.

Two desirable applications of this control measure are the phaseout of inefficient types of domestic oil-fired furnaces and the elimination of on-site incinerators. In an AQMA where greater emission reductions are needed to accommodate expected growth, an extreme application would be the prohibition of new coal- or oil-fired space heating units in a specified area where maintenance action is required.

2. Historical Review of the Measure

a. Current Application. Regulations to prohibit or phase out specific types of sources of air contaminant emissions have been adopted by some air pollution control agencies. Most States have, in one form or another, prohibitions against open burning. Examples of such regulations are presented in table III-2.

The Federal Motor Vehicle Control Program is a recent example wherein specific emission control performance is required on new automobiles to control emissions from mobile sources. As the nationwide vehicle fleet ages, older vehicles become obsolete and are replaced by new vehicles incorporating the emission control equipment.

b. Effectiveness of the Measure in Current Applications. The effectiveness of this measure toward the maintenance of air quality is dependent upon the number of sources that will be eliminated and the spatial distribution of such sources. For a specific AQMA the effectiveness can be determined by adjusting the emissions inventory and subsequent dispersion model.

3. Implementation

a. Procedure. The phaseout control measure is a measure implemented by law but differing from immediate prohibition of equipment or technology by allowing a reasonable time lag between enactment and complete prohibition. This time lag is normally incorporated into the measure by restrictions to new products, thereby using the mean life of the existing product as a transition period. Alternatively, the measure could specify a transition period, in which both new and old equipments are satisfactory, to terminate at a given date after which only the preferred product is legal.

Specifically for oil-fired furnaces, particulate and NO_x emission reduction can be achieved by improved burner design, turbulence control, staged injection of fuel, tangential firing, etc. If adequate performance standards are imposed on new units with prototype testing before they are approved for sale, manufacturers can apply known technology and develop additional design techniques to achieve much better performance than presently observed.

Table III-2. Examples of regulations adopted to prohibit or phase out specific sources of emissions

State	Regulations	General Content
Arizona	Tucson Regulation Governing Street Improvement; August 22, 1972	All new roads must be paved
Connecticut	19-13-G15	Single chamber incinerators, new flue-fed incinerators prohibited
Maryland	43P05 Sec. 0603	Prohibits on-site incinerators, with few exceptions
	0605	New post-January 1971 installations using residual fuel oil in boilers of <5 x 10^6 BTU/hr capacity prohibited
	0605	New post-January 1971 installations using solid fuel in boilers of <250 x 10^6 BTU/hr capacity prohibited
Massachusetts	Boston Reg. 4.3.1	Number 5 fuel oil prohibited in all fuel burning equipment of <4.5 x 10^6 BTU/hr capacity
	4.3.1	Number 6 fuel oil and bituminous coal prohibited in fuel burning equipment of <9 x 10^6 BTU/hr capacity
	5.1	Application of asbestos fiber to any structure prohibited
	6.3.1	Dry sandblasting prohibited
	6.3.2	Wet sandblasting prohibited, except with written permission
	6.4	Spray-coating with minerals prohibited, except with written permission
Minnesota	APC 7	Multiple chamber incinerators only can be used to burn refuse
New Jersey	Chapter 11, 2.1	Single chamber flue-fed incinerators prohibited
	Chapter 2, 2.1	Open burning for salvage operations prohibited
New York	New York City 1403.2-4.03	Installation of new refuse burning equipment except municipal and pathological prohibited
	1403.2-11.05	Use of fuel burning equipment using bituminous coal without control apparatus prohibited (99.5% particulate control required)

b. Conditions of Applicability. Phaseout measures are appropriate for forcing shifts toward desired technology or equipment when more direct or drastic action is impractical. These conditions frequently exist when large amounts of capital investment are involved or when the equipment is pervasive throughout society so that changes can only be made gradually without causing unacceptable disruption or hardship.

When tied to the standard replacement cycle, the added loss in capital caused by phaseout is zero; all capital is fully amortized. The replacement equipment, however, may be more expensive.

Phaseout is only appropriate when an equivalent, less polluting alternative technique exists for carrying out a particular function or service in society. It offers a minimum cost transition procedure with little disruption of normal operations. It is most appropriate for maintaining already achieved air quality standards in that major, drastic steps would not normally be required.

The two example applications of phaseout fulfill these criteria. Emissions from domestic oil burners of inefficient design are excessive; many modern designs have much lower emission rates, but are not any more expensive than alternative new heating units. The effectiveness of the measure also depends on the deterioration rate of the replacement. A low maintenance oil burner should be designed and built for perhaps a 15-year operation within specified performance limits. EPA is presently funding development projects for such equipment. The replacement equipment does not have to be specified in the regulation, and probably should not be unless it is mandatory that a particular replacement technology be employed. However, unless proven alternatives do exist, any phaseout regulation will probably encounter considerable opposition.

Similar comments are valid for the phaseout of on-site incinerators. They can be eliminated from new construction by law. Their function can be handled by conventional community garbage/trash collection and disposal services, possibly including use of refuse compactors in some buildings.

c. Potential Conflicts. Agreement as to when phaseout of a specific source is desirable will not be universal. The optimum technology may not be as debatable as the evaluation of the desirability or need to take steps to switch to it. The economic value of any given phaseout is difficult to quantify when key benefits center around improved air quality.

The most important negative environmental impact is the time lag inherent in this control measure. Phaseout does not have immediate impact on the maintenance of air quality. Rather, it is a long-range control measure that with proper planning yields long-term benefits in air quality.

d. Practical Limitations

1) Social acceptability. Well-conceived timed replacement programs have always been well received by the public, who readily perceive these actions as progress. Public hearings on proposed phaseouts and careful presentation of the impact on air quality will continue to be requisite for public acceptance and the enactment of appropriate regulations.

The current petroleum shortage makes phaseout of oil burners socially acceptable. Reserving fuel oil for uses other than space heating would be accepted by society today as a desirable long-term goal from an energy allocation viewpoint. Obviously, an alternate source of heat must be provided for, such as natural gas, electricity, or gas made from coal.

2) Economic feasibility. A major attraction of this measure is that it makes otherwise uneconomic modifications and transitions economically feasible. One simply does not scrap all automobiles without emission controls. By phasing out such vehicles, the same result is eventually accomplished. The phaseout now underway in the automobile industry causes no disruption to the consumer. Similarly with oil burners and on-site incinerators, a timely phaseout will be economically acceptable and will prevent more drastic measures from being needed later.

4. Evaluation of Control Measure Effectiveness

a. Ability of Measure to Maintain Standards. The impacts of phaseout and prohibition are dependent on the percentage contribution of emissions from the affected source category and the emission rate of the equipment that replaces the obsolete or prohibited equipment. For example, a source category that contributes 5 percent of emissions may be totally eliminated by phaseout of equipment over a 10-year period and replaced by other sources that contribute only 1 percent of base-year emissions. In this case, the measure would cause a 4 percent reduction in total emissions. Generally, these will be area source categories, so their impact on air quality may be even greater than their relative contribution to total emissions in a problem area.

Due to the attrition period normally associated with this measure, its full effect would be spaced over the phaseout period. This long-term, continuing emission reduction is consistent with the intent and needs of maintenance measures.

b. Relative Efficiency When Compared to Other Measures. If the measure is capable of providing a significant part, or all of, the necessary emission reductions to offset projected growth according to emission inventory calculations, it should certainly be considered in the evaluation process. Identification of candidate source categories for phaseout or prohibition should be on a local basis.

D. FUEL CONVERSION

1. Definition of Measure

The discussion in this section is limited to processes whereby one fuel is converted to another form that has a lower pollutant emission rate per Btu. Fuel switching by individual sources, the ultimate result on a regional level of increased availability of cleaner fuels from fuel conversion processes, is described in Ch. III Section E, Energy Conservation and Utilization. Processes in which fuels are converted directly to thermal, electrical, or kinetic energy are not considered here. Some of the conversion processes currently of interest--most of which involve coal conversion--are:

- Coal gasification
- Coal liquefaction
- Coal desulfurization
- Oil desulfurization

Additional processes may become prominent within the initial 10-year air quality maintenance planning period or thereafter.

Most of the fuel conversion plants to be built in the United States will probably be located outside AQMA's. Therefore, the fuel conversion process itself is not really an air quality maintenance measure within the jurisdiction of the AQMA, although the maintenance area will benefit by using the converted fuel. In effect, a remote fuel conversion process will enable an AQMA to benefit from fuel substitution measures.

It is likely that the coal and oil companies will be the owners of most fuel conversion plants that may be built, but present coal consumers such as electric utilities may build the plants to ensure a clean fuel supply for themselves. It is also possible that some other sector of private industry will invest in such plants.

For power plants, fuel conversion serves mainly as an alternative to flue gas desulfurization. It was recently reported (ref. 4) that about 30 percent of projected coal-fired generating capacity will need flue gas desulfurization systems by 1980 to meet emission standards. Since coal conversion plants will probably not be available commercially on a significant scale before 1985, timing requirements alone will probably dictate much more widespread use of flue gas desulfurization techniques than fuel conversion.

2. Historical Review of the Measure

a. Current Application. At the present time, fuel conversion processes are being employed commercially to a limited extent, especially in Europe. Some of the approaches that are presently being considered and the status of development for each approach are discussed briefly below.

1) Coal gasification. Two modes are under consideration at the present time; low Btu gas for utility use and high Btu gas to supplement natural gas for pipeline use.

Commercial coal gasification processes such as the Lurgi and Koppers processes for the production of low Btu gas are available, but no such plant has been constructed in this country to produce gas for electric utility use. Because of the loss of sensible heat necessary for gas cleaning, overall thermal efficiency for a single-cycle plant is 20 to 25 percent lower than for a conventional coal-fired plant. However, if the thermal content of the gas is recovered and if a combination cycle utilizing a steam turbine and a gas turbine is employed, it may be possible to obtain 20 to 50 percent more electric power from a ton of coal than in a conventional coal-fired power plant. At the present time, certain technological problems remain. High temperature gas cleaning methods and reliable high temperature gas turbines must be further developed (ref. 5). In addition, lead times on the order of 5 years are required to design and construct a gasification plant after a large supply of coal is committed for use. The effects of such a plant could not begin to be realized within an AQMA until the early 1980's even if coal gasification commitments were made immediately. It is estimated that gas costs would be on the order of $1.00 to $1.80 per million Btu's (ref. 5). This relatively high cost seems to make the process unattractive; however, costs of other competitive fuels are also rising rapidly.

High Btu gas production to supplement pipeline nature gas can affect air quality maintenance in an AQMA only insofar as the gas supply in the area could not otherwise be sustained or increased. It does not appear likely that such gas will be available in sufficient quantity to permit switching from other fuels until after 1985. At best, the substitute gas may prevent additional industrial switching to dirtier fuels. Present estimated high Btu gas costs range from $1.00 to $2.00 per million Btu's. El Paso Natural Gas Co. has a $270 million plant under construction in New Mexico, due for completion in 1976, so the process may be considered to be commercially available.

2) Coal liquefaction. Processes are now on a pilot or laboratory scale only. It is not expected that technology will be available for commercial use before 1980 and will not make a significant impact on the availability of clean fuel until after 1985.

3) Coal desulfurization. Coal cleaning methods are available and are widely used to reduce the sulfur content of coal. Potential results vary considerably with coal characteristics. For example, a coal washability study by EPA (ref. 6) indicated that a group of coals ranging between 0.6 and 4.4 percent sulfur could be cleaned to obtain sulfur reductions between 4.5 and 68.1 percent. Btu yields ranged from 91.3 to 99.6 percent of that for the unwashed coal.

About 3 percent of the heat content of the coal would be lost in the washing process. Coal cleaning costs, not including value of cost lost in washing, were between $1.00 and $2.00 per ton. In general, it is not feasible to clean coal having less than 1 percent sulfur. Cleaning also reduces fly ash emissions for a given furnace and electrostatic precipitator.

Deep cleaning methods for coal are now in the pilot plant stage of development. One process produces solvent-refined coal either in liquid or solid form. It is estimated that the process can yield low sulfur fuel at a cost of 81¢ per million Btu (ref. 5). Commercial technology is expected to be available sometime after 1980.

b. Effect of the Measure in Current Applications. Since the various fuel conversion techniques are generally not in commercial use, the effectiveness of the techniques cannot be determined. The potential effectiveness of fuel conversion on AQMA air quality is discussed later in this section.

3. Implementation

a. Procedure. Fuel conversion measures generally cannot be implemented on a local level by a control agency. Stringent regulatory requirements on allowable fuel characteristics or emission rates may lead indirectly to the practice, but it still must be justifiable economically in comparison with the use of acceptable natural fuels or emission control systems before it would be undertaken. Thus, an AQMA may be able to take credit for the increased availability of cleaner fuels resulting from a fuel conversion facility, but those responsible for air quality maintenance cannot influence that availability significantly without major subsidization.

b. Conditions of Applicability. This measure has its maximum potential in areas where the consumption of coal and heavy fuel oils is high, and where fuel combustion emissions from area sources are significant. However, since the measure will not be available for several years, applicability is also limited to areas where the control measure is not needed in the near future.

c. Interaction With Other Measures. The effect of this measure in relation to other maintenance measures is to provide a larger supply of clean-burning fuels to an AQMA at prices competitive with existing supplies. Therefore, negative interactions are not expected. Some administrative measures, such as emission density zoning, may be assisted by the availability of synthetic clean fuels from fuel conversion.

d. Potential Conflicts With Community Development Plans. Fuel conversion would act to supplement clean fuel supplies, so it is not expected to conflict with community development plans. This measure would be implemented by the companies and utilities who must plan for and provide the fuels, so their operations would not be adversely affected.

e. Practical Limitations.

1) Social acceptability. Overall public reaction is expected to be favorable since these processes provide a new supply of fuels that are presently being rapidly depleted. Negative aspects would probably be relative to the locations of the conversion facilities, which in this discussion are assumed to be outside the AQMA.

2) Economic feasibility. Cost estimates show that these processes are not currently economically competitive with naturally occurring gaseous fuels. However, increasing fuel prices will alter the situation in the future, especially as natural gas and oil prices increase.

4. Evaluation of Control Measure Effectiveness

a. Ability to Maintain Standards. This measure has a low potential for maintaining standards for two reasons:

- The planning and control agencies have no power to require fuel conversion, nor to specify the amount or type of clean fuels to be produced; also,
- If a supply of converted fuel is made available in a metropolitan area, mechanisms may not be readily available to allocate this cleaner fuel to areas within an AQMA where it would be of most benefit for air quality maintenance. This is because the distributor, presumably the natural gas utility in this case, has established procedures and criteria for accepting new customers and installations. The addition of customer location to the list of criteria would require active participation of the utility in the maintenance effort and approval of the appropriate State regulatory commission. Even if these two requirements were fulfilled, the allocation scheme still may be subject to challenge by rejected applicants.

Coal cleaning will probably find only limited additional applications because washed coals are not capable of meeting SO_2 emission regulations in many jurisdictions. For example, Ohio regulations require emission rates of 1.0 to 3.2 lb/10^6 Btu of SO_2 after 1978 for combustion sources greater than one million Btu/hour input, limits generally unattainable with just coal washing.

b. Relative Efficiency of the Measure. Based on the non-availability of fuel conversion processes on a significant scale within the initial 10-year planning period, fuel conversion cannot be relied upon to provide clean fuel in this time frame. The longer term applications of these processes are, however, almost unlimited, especially in view of the recent increased emphasis on fuels research.

Fuel conversion, as industrial process, may have direct impact on air quality within an AQMA. Economics normally dictates that the conversion process take place at the source of coal, oil shale, or other new material. The buildup associated with the plant and the plan itself may generate emissions that could threaten NAAQS in areas where present air quality is much better than secondary standards. Many of these remote areas have been AQMA proposed as Natural Resource Development Areas in the AQMA designation process.

E. ENERGY CONSERVATION AND UTILIZATION

1. Definition of Control Measure

Optimum use of fuel and energy resources to reduce air pollution emissions encompasses both energy conservation and the redistribution of currently available fuels to combustion sources. Conservation measures are aimed at the reduction of energy demands through more efficient use of energy, as for example, better insulation of buildings to reduce thermal losses. A reduction in energy requirements will decrease the quantity of fuels used by combustion sources, thereby reducing the emissions of pollutants to the atmosphere. A fuels redistribution policy is not intended to reduce the total quantity of fuel used by combustion sources, but rather to reduce the pollutant emissions directly through the use of emission control devices. This can be accomplished through the use of incentives whereby those combustion sources for which control devices are readily available are encouraged to use so-called dirty fuels. Clean fuels are directed to those sources for which control devices are either not available or are economically impractical.

Specific measures which may be considered in the development of an overall energy utilization measure are listed below. This list should not be considered to be exhaustive, as additional measures may be appropriate for a specific AQMA.

Energy Conservation Measures

- Revision of building codes to reduce thermal loss
- Reduction of heating and cooling requirements
- Greater use of multiple family structures
- Energy conservation in industrial processes
- Revised scheduling of industrial activities
- Vehicle use restraints
- Fuel consumption restrictions on new vehicles

Fuels Redistribution Measures

- Incentives to change fuel type
- Prohibition of specific fuels

2. Historical Review

a. Current Applications. Energy utilization measures have had only minor consideration in the development of strategies for achieving and maintaining air quality standards. Prior to the energy crisis, the proposed method of meeting emission regulations for many large combustion sources was a switch to low sulfur fuel oil or natural gas. Many control agencies even adopted regulations prohibiting the use of fuels with sulfur content in excess of specified values. For example, the District of Columbia Air Quality Control Regulation Section 8, par. 2-704 prohibits the burning of fuel oil having greater than one percent sulfur by weight. After July 1, 1975, the D. C. regulation will reduce the allowable sulfur content in fuel oil to 0.5 percent. Because of the energy crisis, there is some doubt as to the feasibility of enforcing this regulation upon users of large quantities of fuel.

Energy conservation measures have come into sharp focus as the full impact of the energy crisis has been realized. In this context, conservation has meaning as a means of satisfying energy requirements in the face of reduced fuel supplies. The Nation has been asked to reduce its fuel usage through lower indoor temperatures during the heating season and higher temperatures during the summer months when air conditioners are being used. Additionally, the public has been requested to reduce the consumption of electricity, especially for ornamental lighting. The higher costs of energy are forcing industrial users to search for production methods with lower energy requirements and to evaluate the economics of reclaiming energy presently being wasted. Finally, by law, drivers of motor vehicles have been required to reduce driving speeds as a means of conserving fuel.

Prior to the energy crisis, a proposal to practice energy conservation as a means of maintaining air quality standards would have been viewed with disfavor by the public. As a result of recent sensitivity, the public reaction to conservation should be much more favorable. It is now apparent that the quality of life need not be adversely affected when energy demands are lowered.

b. Effectiveness of the Measure. Because energy utilization measures have not been adopted by control agencies, there is little information upon which effectiveness can be evaluated. There is some limited information available regarding the effectiveness of some of the individual measures previously identified (refs. 7-10).

- Revision of building codes to reduce thermal loss. At the present time some electric utilities provide rate incentives for electrically heated homes that comply with recommended thermal insulation requirements. The National Conference of States on Building Codes and Standards has recently drafted a model code emphasizing construction that results in reduced energy consumption throughout the life of the building. At least one prototype office building has been constructed to demonstrate a 20 percent reduction in energy consumption in comparison with typical modern buildings.

- Reduction of heating and cooling requirements. Information made available by the Federal Energy Office indicates a 3 to 6 percent savings in heating fuel requirements for each one degree of reduction in indoor temperature during the winter months. Similarly, a one degree increase in temperature during the summer months will result in approximately a 4 percent savings of electricity for air conditioning.

The inclusion of energy conservation measures, such as insulation and storm windows, as mandatory measures in building walls would result in a reduction of energy required heating and cooling. These measures could be made applicable to existing structures by requiring their application during major modification of the structure.

- Greater use of multiple family structures. The goal of many Americans has always been to own their own individual home. From a standpoint of energy conservation, this type of construction is least efficient due to the thermal loss from all four walls, the floor and roof. The use of housing structures with common walls reduces energy requirements by approximately 5 percent for dwellings with a single common wall and up to 40 percent for comparable-sized housing units in large apartment buildings. The enactment of a preferred personal property tax for multiple family structures is one incentive for greater use of this mode of housing.

- Energy conservation in industrial processes. Many energy conservation and recovery techniques for industry are described in the following section, "Combination of Emission Sources," as applications of total energy systems.

- Revised scheduling of industrial activities. Electrical power generating facilities are designed to meet the demand for electricity as it occurs. In many areas, there are generating plants used for base load and others used for peak loads. In some instances, the peak load plants are older units that have been consigned to such duty because of their higher pollutant emission characteristics. Peak load plants are often in the core area while baseload plants are in isolated areas. It may be possible to reduce some of the peak load requirement by scheduling industrial operations with large electrical demands at off peak hours, thereby reducing emissions in urban areas. The net effect upon air quality resulting from such actions must be determined on a case-by-case basis.

- Vehicle use restraints. The net reduction in vehicular emissions resulting from various use restraints are discussed in chapter II, section E,"Transportation Controls."

- Fuel consumption restrictions on new vehicles. Minimum gasoline mileage requirements for new motor vehicles on cursory examination appear to provide an additional reduction in average vehicle emission rates beyond the FMVCP, due to the combustion of less gasoline per mile of travel. However, the Federal certification test results for the 1974 model year vehicles, published in 39 CFR 7663, indicate that vehicles that are more efficient in gasoline usage do not produce significantly lower emissions of hydrocarbons, carbon monoxide, or oxides of nitrogen than vehicles with high gasoline consumption rates. Therefore, it is doubtful whether this particular energy conservation program will have corresponding emissions reductions.

- Incentives to change fuel types. Conceptually, it should be possible to provide an incentive of some type to encourage some fuel combustion sources to change fuels. Ideally, the plan would be to burn dirty fuels in large sources for which control hardware is feasible. This, in turn, would allow the smaller and more numerous sources to burn clean fuels. The incentive, in the form of a tax break, would then help to offset the added cost of control hardware. Because of contractual arrangements with fuel suppliers and the tremendous costs that would be entailed in establishing meaningful incentives, in many cases it is not advisable for State and local pollution control agencies to become involved with this problem. The application of stringent emission limitations on small sources could provide an incentive for use of clean fuel by making it less costly than the installation of emission control equipment. Conversely, the selective application of a tax on clean fuel used in large units would provide an incentive for the use of emission controls, thereby releasing the cleaner fuel for use elsewhere.

- Prohibition of specific fuels. The prohibition of specific fuels is now a part of some control agency regulations. The effectiveness of such regulations must be evaluated on a case-by-case basis. Dispersion modeling and rollback methods can be used to determine air quality resulting from changing emissions of point and area sources.

3. Implementation

In this period of rising fuel costs, which will certainly persist into the foreseeable future, the control agency can expect great assistance from the populace for an energy utilization policy. In the short run, energy conservation through reduced heating and cooling demands can be nurtured by an active public relations campaign. A program designed to keep the public aware of the savings in fuel cost by the proper control of indoor temperatures should suffice. Compulsory energy conservation programs for air quality maintenance have not yet been proposed.

The implementation of energy utilization measures beyond that described in the preceding paragraph requires the air pollution control agency to depend heavily upon other governmental and official planning agencies. Revision of building codes obviously requires an effort upon the Building Inspection group to modify existing codes. A move toward the construction of multiple family structures with common walls requires cooperation with community planners, builders' associations, and real estate brokers associations. To effect revisions of industrial activities requires the support of Trade Associations, Chamber of Commerce, Electric Utility Companies, and the affected industries.

a. Conditions of Applicability. Energy utilization measures should be directly applicable to any AQMA. Certainly, the driving force, especially relative to conservation, will be from the users of energy who are being required to pay continually increasing costs for energy.

b. Interactions with Other Measures. This measure does not have a significant interaction with most other maintenance measures. The one exception being that the concept of greater use of multiple-family units must be incorporated into community development plans.

c. Potential Conflicts with Community Development Plans. Energy utilization measures are not clearly in the domain of a single regulatory agency. It is not clear that such measures will be regulated by a single authority in the future. On the assumption that energy utilization measures will be controlled by more than one jurisdictional body, it is inevitable that conflicting aims of these bodies will create regulatory difficulties. On a national level, it is obvious that the aims of the Environmental Protection Agency, the Federal Energy Office, the Department of Agriculture, the Labor Department, and other departments have interests that would affect energy utilization policies in different ways. On a regional level, diverse counterpart agencies will also have particular self-serving interests that may not be entirely compatible.

d. Practical Limitations.

1) Social Acceptability. A commitment to energy conservation efforts will probably be received well by the general public. Such a policy will tend to hold costs down and will impose no particular burden on the general public as long as the policy does not result in a deterioration of the quality of life.

Voluntary commitments to energy conservation by the public will probably also be received well, as long as the commitments do not significantly affect the living conditions to which an individual is accustomed. The least acceptable strategies will probably be those that commit the public to an austerity measure on a regulatory basis, but such strategies will likely be the ones that yield the greatest benefit.

2) Economic Feasibility. These activities must be evaluated on a case-by-case basis. Some approaches may be adopted voluntarily because the approaches are feasible. Others may be nearly impossible to implement because they are inherently uneconomic, and because the environmental returns cannot be predicted with sufficient reliability to justify economic investment that might be necessary.

4. Evaluation of Control Measure Effectiveness

a. Ability of Measure to Maintain Standards. The activities that may be viable in this measure will each probably have small capabilities in themselves. It is, therefore, doubtful that the measure can generally be used by itself to maintain standards. In most successful applications, several measures will have to be used collectively.

The ability of enery conservation measures to reduce emissions is dependent on the specific nature of the measure. However, the following general model can be used to estimate the emission potential of energy utilization measures.

For Fuel Redistribution Measures

Potential Emission Reduction = $[E_a - E_b][\text{Btu}]$

Where:

E_a = Controlled emission rate per 10^6 Btu heat input under existing conditions

E_b = Controlled emission rate per 10^6 Btu heat input under changed conditions

Btu = Energy requirements (10^6 Btu) for the time frame under consideration

For Energy Conservation Measures

Potential Emission Reduction = $E[Btu_a - Btu_b]$

Where

E = Controlled emission rate per 10^6 Btu

Btu_a = Energy requirements (10^6 Btu) under existing conditions for time frame under consideration

Btu_b = Energy requirements (10^6 Btu) under control measure for the time frame under consideration

Data available within the State can serve as a source of information for determining emission rates. Design specifications may also provide such information. Should these sources not be adequate, emission rates can be estimated using data in AP-42 and actual or expected efficiency of the control equipment.

For fuel redistribution measures, total energy requirements can be obtained from NEDS, local fuel consumption records, or from the facility itself. For energy conservation measures existing, total energy requirements can be obtained from the sources listed above. Engineering estimates can generate the energy requirements under the energy redistribution measures.

b. The various activities within this measure may be cost-effective in terms of pollution control. The magnitude of the reduction will be dependent on the contribution to the total emission inventory by the source categories to which this measure is applied.

F. COMBINATION OF EMISSION SOURCES

1. Definition

The underlying assumption of the combination of emission sources (CES) measure is that it may be beneficial from an air pollution viewpoint to combine a large number of small uncontrolled emission sources into one large, well-regulated, and well-monitored emission source, emitting from a taller stack. Such combinations not only result in better emission control but also simplify enforcement as well. Combination of emission sources may produce an economic advantage because of the increased efficiency that usually results from economies of scale. As a part of sound air quality management, however, it must result in a net emissions reduction of pollutants into the atmosphere.

Two applications of this measure are emphasized in this section: a) district heating, and b) district incineration. These applications are complementary in that the facility used to provide one service may also provide the other; e.g., a district power plant can be built that furnishes heat, hot water, and electricity to a neighborhood and at the same time uses the solid waste of that neighborhood as part of the fuel charge to generate these consumable energies. This combination of emission sources involves dissimilar types of sources (power generation emissions and solid waste disposal emissions). A more conventional combination of sources involves the replacement of a large number of similar sources by a single source of the same generic type. This plan is less attractive when applied to home heating, as will become evident. It is not until the properties of a total energy power plant combination are considered that the air pollution advantages of this measure become compelling.

As might be expected, the optimum strategy often depends upon independent assumptions. For example, if natural gas is assumed to be readily available to meet the requirements for most urban residential/commercial growth, the concept of district heating is not nearly as attractive as if coal must play a significant role. A brief discussion of existing residential/commercial sources puts the problem in a realistic perspective.

In 1970, stationary combustion accounted for significant fractions of total particulates (≈25 percent), sulfur oxides (≈80 percent), and nitrogen oxides (≈45 percent). Carbon monoxide (≈0.06 percent) and hydrocarbons (≈1.6 percent) emissions from stationary combustion sources were relatively insignificant as a fraction of nationwide totals (ref. 11). Reducing the carbon monoxide or total hydrocarbon output from stationary sources would have very small impact on total air quality. Consequently, any strategy for reducing emissions from stationary sources must pay off in improved air quality with respect to particulates, SO_2 or NO_x.

Particulate emissions from stationary sources are classified according to fuel type (coal, oil, or gas) and source category (electric utility, industrial, or residential/commercial). The CES measure applies primarily to the residential/commercial source of emissions, since electric utilities and industrial sources already consist of large, centralized power stations. Further combinations or centralization of these sources are not the objectives of this measure, although such combinations may be economically very attractive as well as beneficial to air quality. It is primarily the combination of various fossil fuel combustion sources in the residential/commercial sector that will be emphasized.

Particulate emissions from the residential/commercial sector constitute about 8 percent of the nationwide particulate emissions. Of this small fraction, coal contributes about 59 percent (oil, 29 percent; gas, 12 percent) but, at the same time, furnishes only about 3.5 percent of the total energy needs of the residential/commercial sector (oil, 44 percent; gas, 52.5 percent)(ref. 12). Clearly, coal is a dirty fuel and gas is a clean fuel. Replacing all coal burners with natural gas would be a most effective measure for reducing particulate emissions from stationary sources.

In 1970, the total energy generated by stationary sources was approximately 3.45×10^{16} Btu's. Coal accounted for only about a fourth of this energy but about 93 percent of the particulate emissions. Replacing all coal combustion processes with natural gas combustion would have reduced total particulate emissions in 1970 to about 617,000 tons, or less than 10 percent of their actual value. If all stationary combustion processes used only natural gas (replace both coal and oil with natural gas), the total particulates emitted in 1970 by stationary sources would have been about 334,000 tons or about 5 percent of what they actually were. A more effective control measure is hard to imagine. But it is also hard to imagine a measure less likely to be implemented.

Natural gas is growing less plentiful in comparison with the demand. Gas suppliers are now declining to accept new customers in certain parts of the country. Utilities are switching from either natural gas or oil to coal. Fuel availability dictates such conversions, but these switches may have an adverse effect on air quality, unless accompanied by suitable process control.

Comparison of SO_2 and NO_x emissions from the three fuel sources also shows coal to be the greatest polluter. It is not likely that air quality would be improved by replacing domestic natural gas-fired furnaces with centralized coal-burning power plants. Indeed, quite the reverse is true. Even with the best controlled combustion processes and state-of-the-art effluent scrubbing, the total emissions would be increased by such a change in equipment.

Switching from a large number of individual residential gas furnaces to a single source of power, burning that same gas, does not produce a significant change in SO_2 or particulates emitted, while the NO_x would be increased by up to an order of magnitude because of the higher temperatures employed in the larger combustion unit.

The same general conclusions apply to replacing individual oil furnaces by either a central or coal-fired power station or a central oil-fired station. Simply combining a large number of small, individual residence space heaters into one large, centralized district furnace is not necessarily an attractive measure based upon simple combustion/pollutant considerations. This conclusion can be changed, however, if the combination of sources is such as to improve the overall efficiency of fuel utilization. This concept, called total energy utilization, reduces air pollution by better utilizing the energy content of fuels so that less total fuel has to be combusted. Consider the utilization of waste heat during the generation of electirc power. Most power plants generating electricity from fossil fuels do so at an efficiency of about 30 percent--typically 30 percent of the energy content of the combusted fuels leaves the generating station as kilowatthours. One large source of lost energy is waste heat discharged into the atmosphere or cooling water. In the total energy concept, a significant portion of this waste heat is used to heat the water and living spaces of the same community that uses the electricity.

This total energy concept is the application of the measure that appears most promising for the district heating/cooling of residential/commercial areas and is the version of source combination recommended here. Similar CES measures apply to many industrial situations but these are too varied and specialized to be considered in any detail.

A conventional electric utility operates at an efficiency of up to 39.2 percent (this efficiency is the highest reported, being attributed to Marshall Unit No. 3 of Duke Power Company, Marshall, N.C., ref. 10). Nevertheless, when transmission losses are also included, the net energy delivered to the customer corresponds to 36,400 Btu's equivalent electrical energy for 100,000 Btu's of fuel consumed.

In the total energy system, the power plant is located in the neighborhood that utilizes its output and delivers both electricity and steam, the latter being used for both space heating/cooling and hot water heating. This double duty achieves an impressive gain in efficiency of fuel utilization as represented by the 77 percent efficiency estimate. The waste heat from power generation, if fully utilized, is even now more than sufficient to heat every home in America (ref. 14).

This maintenance measure achieves an impressive gain in efficiency by moving the power plant into the neighborhood so that normally wasted heat can be substituted for individual home space and water heating and cooling. At the same time, air quality considerations dictate that the fuel used to fire the neighborhood power plant have low emissions. The reduction in air pollution comes about not because of greatly reduced emitted pollutants per unit quantity of fossil fuel consumed but primarily because of the reduced total fuel requirements of the neighborhood which in turn corresponds to reduced total pollutants.

Another very desirable feature of a total energy power plant is design of the combustion chamber so that it can accept at least part of the solid waste of the community as part of its fuel charge.

2. Current Applications

The CES measure is becoming more popular because it conserves energy, reduces costs, and reduces total emissions. Numerous illustrations of CES in practice now exist. They range in size and scope from industrial applications involving one or two companies to large area residential applications involving a large number of apartment dwellings or even a whole city. Some examples of each are reviewed in this section.

Perhaps the simplest implementation of the CES measure is the relatively common industrial application in which an extraction turbine, used to generate plant electricity, is also used to furnish low pressure steam for in-plant use. High pressure steam is generated in a boiler which drives the turbine. Low pressure steam is bled off or extracted and circulated through the plant distribution system for use in industrial processes or space heating.

This measure is widely used in industry and has evolved into cooperative ventures between separate companies such as a steam user and an electric utility. By locating the separately owned and operated steam generating and steam-using facilities adjacent to each other, the waste of one industry becomes an input to the other.

The economic benefits that occur from a total energy facility can be illustrated by comparing the overall fuel use efficiency of such a plant with that of a conventional steam-electrical plant. Standard Oil of Kentucky operates a steam generating plant at Pascagoula, Miss., which in addition to providing electricity to the Mississippi power grid also supplies steam to the refinery. Overall efficiency, in terms of utilization of energy input, is 61.5 percent. This is compared with the Gulfport plant of Mississippi Power Company which has an overall efficiency of 27.6 percent operating in the conventional mode.

Many examples of similar utility-industry partnerships exist, but many more industrial opportunities could be developed to take advantage of this largely wasted energy source. Any industrial process using high temperatures is a potential candidate for the CES measure.

A technique still being developed by the power generating industry is the use of a combined gas turbine/steam turbine generator in which the exhaust gas of the former serves as the primary or sole heat source for the latter. Conventional steam generators use fossil fuel to generate steam which in turn drives a turbine to generate electricity. In a gas turbine, the expanding, burning fuel serves as the primary driving fluid for the turbine (like a jet aircraft engine). The exhaust gases of the gas turbine exit at very high temperatures and can be used to heat water for steam. This two-stage combination (both the gas turbine and the steam turbine generate electricity) operates at efficiencies exceeding 50 percent, a significant improvement over either one alone.

In most potential applications of waste heat, the temperature of the exhaust fluid from a generator that is most useful in industrial or even residential/commercial applications is not that which corresponds to the most efficient power plant operation. Steam or hot water generally must be drawn off at a higher exhaust temperature than would be chosen for highest generating efficiency alone.

Use of power plant heat in district heating of residential/commercial living space is also currently operative. Consolidated Edison supplies Manhattan with a peak of about 3,000 MW of heat, a major portion of which is obtained from extraction and back-pressure turbines. Hospitals, university complexes, and military/government installations have employed central/ district heating concepts for years.

The total energy concept to be described here as an optimal CES measure is an updated version of centralized district heating for the residential/commercial user. As the name implies, total energy plants furnish all required energy to their customers. The prime justification for such a scheme is still economic, but there are significant secondary advantages, including reduced air pollution.

Union Electric Company in St. Louis now consumes 300 tons of solid waste per day with which it generates 12.5 MW (ref. 15). This facility has been in operation since May 1972. The process mixes residential solid wastes with pulverized coal to generate electricity. The only refuse processing is the removal of magnetic metals and the pulverizing of the remainder in a hammermill. The milled refuse has a heat content of roughly 5,000 Btu's/lb., about 40 percent that of good quality bituminous coal.

The combination of solid waste fuel with a district heating/cooling power plant should be in operation in Nashville, Tenn., in early 1974. This project is designed to provide central heating and air conditioning to 27 office buildings in downtown Nashville and has the capability to service 16 more buildings should initial results warrant expansion.

Tokyo plans disposal facilities that will use garbage to provide heat and hot water for homes near the incinerating facility. Paris now operates steam-electric plants with an annual charge of 1,600,000 tons of garbage. Both electricity and steam are thereby generated in incinerators equipped with pollution controls.

On the industrial front, Goodyear Tire and Rubber has developed a boiler that utilizes old tires for fuel.

The advantages of using solid waste as a direct fuel are that two significant emission sources can be controlled in one facility, and refuse is a low sulfur fuel. Solid waste disposal is a major source of air pollution. By incinerating it in a well-monitored power plant, its emissions can be limited, and at the same time the total fresh fuel requirements of the community can be reduced. The total energy version of CES is economically advantageous not only in fuel costs but also in reducing the disposal costs of solid wastes. Transportation of solid waste to distant disposal points is costly. Using it on-site or in the neighborhood in which it is generated greatly reduces these moving costs and reduces emissions that would result from the transportation of solid waste to remote disposal areas.

3. Implementation

a. Procedure. The CES measure is primarily a feature to be incorporated into new urban development. Since heat distribution requires the installation of either buried or overhead high-pressure plumbing as well as compatibility with fixtures in the individual residence, retrofitting existing neighborhoods is prohibitive. For new construction, however, it is quite easy to incorporate the plumbing and compatible fixtures into each residence or separate structure as it is being built. The necessary outside plumbing can be installed along with conventional water and sewer service. In certain areas the existence of a district power plant may be planned as a future facility, but all new construction could be required to incorporate the necessary tap-on lines and compatible distributing equipment. For the time period prior to the availability of central power, the space heating/cooling requirements can be met by the conventional gas or electric equipment now used in individual residences.

Coal-fired power generators should be restricted to remote sites. Again, the waste heat should be used in conjunction with industrial processes that are also located remotely. A very acceptable arrangement would be to locate the coal-fired generator at the mouth of a coal mine and utilize the byproduct heat as process energy for coal gasification--the production of synthetic gas which can be piped to urban areas for use in total energy power plants.

A guiding rule for the CES measure is that no future power generating equipment should be constructed without either utilizing its "waste" heat or justifying its failure to do so.

b. Criteria for Applicability. The conditions under which this measure are applicable can be very broad; it can apply to all new residential/commercial development or it can be restricted to only certain types of new construction. It is clearly well suited for densely populated urban areas being developed. It has been used in Vasteras, Sweden, to supply the needs of 90 percent of the city's 120,000 people and has "blessed the town with 'Sweden's purest city air'" (ref. 16). This particular installation is oil-fired and employs high temperature hot water for transporting home heat. Return hot water is 55° to 70°C, sufficiently warm to melt the ice and snow from the center of the city's main streets. This system, operating in a cold climate, produces cleaner air than the individual coal- and oil-heating systems it replaces at a lower cost to the subscribers.

It is also applicable to urban developments in temperate or warm climates, for the steam generated can be used to power absorption-type cooling equipment, thereby providing centralized space heating/cooling on a year-round basis.

Housing developments under the design of one builder can easily adopt this measure. Smaller developments under multiple sponsorship can be combined into one power plant district by municipal planners, much like present city sewage and water services are planned.

The measure applies to industrial users who are already highly motivated to reduce operating costs and at the same time already possess the authority and technology to incorporate the CES measure into the design of new facilities.

The CES measure can also be implemented in the design of individual homes. The waste heat from the furnace flue could be used to preheat the charging water for the hot water heater, or the exhaust from the clothes dryer or dishwasher could be used to heat and humidify the home during the winter, etc. This approach could serve as a secondary strategy for rural or remotely located dwellings, which may be judged to be too far away for direct heat transfer and inappropriate for all-electric service. The common strain unifying all these examples is the combination of emission sources by designing one piece of equipment to do the job now performed by two or more. The desired result is less total energy required and, hence, less emitted pollutants.

All CES measures have the common advantage of reducing total fuel consumption. This end result, which is highly desirable with respect to energy conservation, produces less net emissions of pollutants simply because less fuel is burned.

No specific numbers are yet available to show that a given density of living space per unit area of land is necessary to justify a certain size total energy power plant. Quite likely, some form of this strategy applies to all new construction. New construction of all forms should be reviewed with the CES measure in mind.

c. Interaction with Other Measures. The CES measure that removes fossil fuel combustion from the individual residential unit and replaces it with a community plant is either compatible or complementary with most other strategies discussed in this planning document. CES provides a well-controlled source of combustion for home heating with minimum air pollution.

Typical interactions of the CES measure with other measures discussed in this guideline document are:

1) Transfer of emission source locations. A primary example of this measure is the shifting of power plants from central locations in the midst of populated urban areas to more remote sites supporting few other emission sources. For purposes of using off-gases of power plants as a source of steam for space heating or water heating, transfer of emission source locations would be counter to many CES applications unless it were feasible to locate industries that could use the waste heat in the neighborhood of the power plant. However, such location of a labor intensive industry could result in an increase of emissions from the housing and service facilities that would be attracted to the area.

2) Phaseout of specified sources. Two specific sources that are candidates for phaseout are on-site refuse incinerators and inefficient oil burners. The CES measure is compatible with both. Not only would inefficient oil burners be replaced by an efficient heating plant but all home heaters, inefficient or otherwise, that depend upon fossil fuel combustion would be phased out. The replacement of many small individual heating units by a single large capacity unit operated and maintained by heating professionals is the heart of the CES measure.

Extending the function of the combustion chamber to serve as a central refuse incinerator for the same area is a bonus, if and when implemented. On-site incinerators would be replaced by a well-controlled municipal-type incinerator. The CES measure can therefore act as a phaseout measure as well.

3) Stack height regulations. The CES measure facilitates implementation of a stack height regulation. The stack height, plus a definition of the minimum acceptable effluent scrubbing and monitoring, become part of the centralized power plant plan. Not only will a large number of small furnace discharges be replaced by a single, well-processed effluent but the height of the emission source can be much greater than would be practical for the many small sources replaced.

4) Energy conservation and utilization. The CES measure recommended here really is an energy conservation measure. CES works primarily because it reduces total fuel needs--conserves energy--by combining many separate energy conversion units into a single, more capable and versatile unit that can do the jobs of all units replaced at lower fuel cost.

d. Potential Conflicts with Other Community Development Plans and Potential Negative Environmental Impacts. The CES measure reinforces present trends toward urbanization of the population. Adoption of the CES measure could make population dispersal more difficult and costly, although not prohibitively so. An effective CES measure would influence growth patterns in addition to centralizing population. Those areas most attractive for new building would be those already incorporated into a master plan for total energy plant location.

Central power plants with tall stacks are difficult to make into esthetically appealing structures. In a few cases, the tall stack can be inside a tall building and thus not be unsightly. In high density areas, where their justification is greatest, the real estate they would occupy would be expensive. Present zoning ordinances may prohibit the building of power plants in many areas where they would be needed to implement the CES measure.

e. Practical Limitations

1) Social acceptability. Social acceptability of CES is probably good, although some objection to "losing control" of a vital home comfort feature such as heating might be voiced. This loss of control is not real, for individual control of unit or even room heat could be maintained. The subscriber would buy heat from the central

plant much like electricity or natural gas is metered into a home. Eventually, subscribers would realize that there is considerable advantage in turning over all maintenance and operating responsibility to the facility's engineering staff.

The overall impact of the CES measure upon the community's lifestyle is minimal. CES favors closely grouped high rise multiunit dwellings, a residential form that has been growing in popularity.

2) Economic feasibility. When implemented at the community planning stage, the CES measure would almost always prove economically advantageous. The costs of the services and utilities received (space heating/cooling, hot water, electricity) invariably prove to be less than if delivered by the conventional means. Indeed, the major impetus for this type of plan in the past has been reduced costs, and, more recently, energy conservation. Reduced air pollution comes as a bonus.

While no record can be found of an economic or technological failure of communities or residential units adopting a CES measure, all these published accounts reflect careful planning under optimum circumstances. Often, these well-publicized projects have been publicly funded as demonstration models, and the size of the community and its location have been carefully selected as near ideal settings for successful operation. Before compelling all new construction to follow this measure, experience in less ideal or marginally suitable locations should be considered.

Widely dispersed, rural settings are not appropriate customers for processed energy other than electricity. The question then arises as to the economic feasibility of supplying all remotely located consumers with electricity for home heating/cooling, hot water and cooking; that is, should all homes outside the steam or hot water range of a centralized energy plant (that this range is not well defined compounds the problem) be required to be totally electric homes? Should rural homes just be declared beyond the scope of the CES measure and ignored?

A key piece of information for resolving these questions is the economic feasibility of electric home heating. If electric heating were as efficient and economical as direct steam heating, fewer problems would exist. The CES measure could be implemented on a 100 percent basis for all new residential construction, urban or rural. Growth patterns would have to be anticipated or controlled so that a market always existed for the waste heat accompanying electric power generation, but the chief decision would be to size the power plant and the range of its steam or high temperature hot water lines. The technical/economic decision would be simply one of determining the range at which energy is more economically transmitted as steam than as electricity.

Electric home heating at present uses about twice as much fossil fuel as do direct heating methods such as gas or oil furnaces in which combustion takes place on site. The relatively low efficiency (30 percent) for converting Btu's of fuel into Btu's of electricity at a typical utility power plant accounts for most of the higher fuel requirements. Consequently, energy conservationists criticize the growth of total electric homes on this basis. If, however, much of the waste heat used in generating electricity can be recovered in a useful industrial, commercial, or residential application, the penalty for electric heating is greatly reduced or eliminated. In addition, electrically heated homes usually can be better insulated and sealed up than a combustion heated home, which requires ventilation for the combustion process (this advantage also applies to all total energy homes). The superior insulation reduces the cost penalty of an all-electric home. In most cost comparisons between electrically heated homes and oil-heated homes, the energy required to deliver the oil to the home is neglected. Transportation costs for providing a home with oil are eliminated in the electrically heated residence (as in a gas-heated residence).

And, finally, the totally electric home is compatible with the nuclear age in which low cost electricity will be generally available. In this sense, the all-electric home will help smooth the transition from the fossil fuel age to the nuclear age. The compatibility of electric home heating with all types of fuel and power sources is a distinct advantage for future community growth.

The availability of improved and more reliable heat pumps may influence the energy/cost balance and is already accelerating the popularity of total electric homes. Heat pumps are single units that can both heat and cool space. They transfer heat from one location to another and the direction of heat transfer is reversible.

Heat pumps are powered by either heat (vapor absorption) or by electricity (vapor compression). They are compatible with the CES measure, and provide a convenient, point-of-use equipment suitable for both heating and cooling in either the steam-heated zone or the electrically heated zone of a CES area. They are more economical than electrical resistance heating and comparable in energy demands to direct heating with gas or oil (ref. 17).

4. Evaluation of Control Measure Effectiveness

The CES measure is most effective for urban areas with high heat volume requirements per unit land area. Consequently, if, as predicted, 90 percent of the population lives in urban areas by the year 2000, the CES measure becomes increasingly relevant in the 1975-1985 period. It can be implemented only in new construction and therefore requires a long lead time to achieve full impact.

a. Ability of Measure to Maintain Standards. The effectiveness of the CES measure can be determined by a comparison of total fuel requirements for the combined system versus the conventional facilities to be supplanted, assuming that the same fuel is used in both cases. The CES alternative can then receive further credit for air quality improvement due to:

- A lower emission rate per unit of fuel burned;
- More efficient control equipment; and/or
- Taller stack height and higher exit velocity.

Data already available from those communities or installations now employing some form of CES measure show greater than 60 percent efficiency of fuel utilization, compared to 25 to 40 percent for conventional systems and an average of 25 percent reduction in costs. Data to show air quality improvement are not generally available, but the reduced fuel requirements clearly correspond to reduced total emissions.

The net emission reduction that can result from implementation of CES can be determined from the following formula:

$$\text{Net reduction} = N\,H\,(E_s - \frac{E_{ces}}{K})$$

where

N = Number of individual units to be replaced by a central system during the time frame under consideration

H = Average capacity of individual units

E_s = Controlled emissions from the average size individual unit expressed as tons of pollutants per unit capacity

E_{ces} = Controlled emissions from the central system expressed as tons of pollutant per unit capacity

K = Factor representing transmission losses

Potential sources of input information are:

N - Growth pattern from land-use planning agencies
Population projections
State planning data

H - Manufacturers' design data
Fuel consumption data for district heating

E_{ces} - Manufacturers' design data
EPA publications

K - City and County engineers
Consulting engineers
Industry

The CES measure has the desirable advantage of reducing a large number of uncontrolled and largely uncontrollable sources to a manageable number of sources under much better control and direction. It can be applied to virtually all new fuel combustion sources, so it is a feasible measure for at least three pollutants and can be quite effective in growth areas where maintenance of any standard is endangered by fuel combustion sources. Also, the measure can be employed specifically in those areas within the AQMA where air quality maintenance is most difficult (hot spots).

The CES measure offers the opportunity for community growth at minimum additional pollution load and lends itself to easy monitoring and control.

b. Relative Efficiency Compared to Other Measures. One alternative measure to CES is to upgrade the reliability of home-sized fossil-fuel-burning equipment. Like the auto industry, manufacturers could be compelled to guarantee a minimum life of unattended operation during which time emissions are not permitted to exceed certain levels. Equipment would be inspected before leaving the factory and possibly spot checked periodically after being in service.

The CES measure recommended here is easier and less expensive to implement. Because of the anticipated higher efficiency of fuel utilization, less total pollutants would be emitted than with an alternative measure such as outlined above.

CES is almost entirely limited to new and modified sources, so it affects the growth component of regional emissions rather than requiring additional control of existing sources. While this is normally an advantage for maintenance measures, it does limit the regional impact of a control measure to only a portion of the total emissions.

G. SPECIAL OPERATING CONDITIONS

1. Definition of Measure

The measures described in this paragraph can be used to reduce emissions from sources on an intermittent basis or to minimize emissions under atypical conditions in order to maintain air quality standards that otherwise might be exceeded for relatively short periods of time. Two principal types of activities are discussed: a) supplementary control systems and b) procedures applicable to malfunction, startup, and shutdown operations.

A supplementary control system is a system "whereby the rate of emissions from a source is curtailed when meteorological conditions conducive to high ground-level pollutant concentrations exist or are anticipated" (ref. 18). A typical application would be a coal-fired power plant that can reduce its load during adverse meteorological conditions so that unsatisfactory ambient SO_2 levels do not result.

Specific operating procedures frequently must be followed in order to minimize the pollutant emissions from particular industrial sources during periods of startup or shutdown and when malfunction of process or pollution control equipment occurs. With respect to new sources, the Federal law provides that under these conditions, industrial processes will be considered to be in compliance on the basis of most recent compliance tests, as long as opacity regulations are not violated during atypical operating conditions. However, the process may not be eligible for such consideration in cases where an upset condition can be shown to be an avoidable situation. This provision is clearly indicated by the EPA definition given for "malfunction":

> 'Malfunction' means any sudden and unavoidable failure of air pollution control equipment or process equipment or of a process to operate in a normal or usual manner. Failures that are caused entirely or in part by poor maintenance, careless operation, or any other preventable equipment breakdown shall not be considered malfunctions (ref. 19).

A specific reporting procedure to be used in conjunction with malfunction operations, applicable to new industrial sources, is included in 40 CFR, part 60, "Standards of Performance for New Stationary Sources". It appears that a procedure requiring all reasonable means to minimize emissions during startup, malfunction, and shutdown of existing sources would be appropriate on a State level as a maintenance measure.

2. Historical Review of the Measure

a. Current Applications. Supplementary control systems function to curtail emission sources on a temporary basis, so that air quality levels remain satisfactory under adverse meteorological conditions. Useful applications are probably limited to specific isolated industrial SO_2 sources, such as coal-fired power plants and nonferrous smelters. Enforcement is not feasible in areas where there are multiple sources of a given pollutant.

The Tennessee Valley Authority (TVA) has undertaken to limit SO_2 emissions from several power plants by reducing generating load and/or burning low sulfur coal during adverse plume dispersion periods (ref. 20). At the Paradise steam plant, early tests determined that the addition of a third unit, at full-load operation, would cause the 3-hour standard for SO_2 to be exceeded during certain meteorological conditions. Three methods of noncontinuous SO_2 emissions control were tried. Plans using low sulfur coal and the addition of lime to the coal prior to conveying the coal to the bunkers were discarded in favor of plant generating load reduction.

Nine meteorological and plume dispersion criteria were established to determine the critical atmospheric conditions that cause high SO_2 levels. When all nine criteria are met, as determined by on-site measurement, generating reductions are determined and initiated. The only limitation on the system is that reductions that would cause power system instability cannot be made. The frequency distributions of measured SO_2 concentrations before and after the implementation of this supplementary control system are given in table III-3.

A supplementary control system for SO_2 is also being used at a copper smelter in the State of Washington. The Puget Sound Air Pollution Control Authority reported that at one monitoring station near the smelter the frequency of 1-hour SO_2 concentrations exceeding 0.25 and 0.5 ppm has dropped significantly since initiation of the supplementary control system (ref. 18). Seven other monitoring stations in operation since 1971 showed similar declines. The frequency of SO_2 levels exceeding 0.25 and 0.5 ppm are given in table III-4.

Proper maintenance and operating procedures have been established for many industrial operations. When maintenance procedures are not followed, it is likely that excessive emissions will result, especially during periods of startup, shutdown, or malfunction.

For example, maintenance requirements for coke ovens are particularly severe. If coke-side and push-side doors are not cleaned properly, the doors will not seal. Smoke will then be emitted from the oven throughout a large portion of the coking cycle. If flues become plugged, "green pushes" may result in a substantial increase in particulate emission rates.

Since maintenance of air quality is highly dependent on adherence to proper maintenance policies and operating procedures, it seems proper that the local agencies should require industries to demonstrate the adoption and use of such policies. New sources are required by Federal law to file quarterly reports of all periods of excess emissions due to startup, shutdown, malfunction, or other causes. The report must also include an indication of corrective measures that are taken and of preventive measures adopted. Owners and operators are required to use acceptable operating and maintenance procedures. Such use may be determined by Federal authorities on the basis of monitoring results, opacity observations, review of operating and maintenance procedures, inspections, and other information. An equivalent State or local regulation, applicable to all sources, would be useful.

Table III-3. Frequency distribution of measured SO_2 concentrations before and after implementation of supplementary control systems at Paradise steam plant

3-hr average SO_2 concentration distribution			24-hr average SO_2 concentration distribution		
3-hr average SO_2 conc. range (ppm)	Frequency		24-hr average SO_2 conc. range (ppm)	Frequency	
	Before (1/1/68-9/19/69)	After (9/19/69-6/25/71)		Before (1/1/68-9/19/69)	After (9/19/69-6/25/71)
0	51,097	55,961	0	3,064	3,752
0.01-0.10	10,574	9,363	0.001-0.02	4,248	4,043
0.11-0.20	443	275	0.021-0.04	400	305
0.21-0.30	102	59	0.041-0.06	92	73
0.31-0.40	37	28	0.061-0.08	24	19
0.41-0.50	16	10	0.081-0.10	14	9
0.51-0.60*	7	2	0.101-0.12	6	3
0.61-0.70*	2	0	0.121-0.14	4	2
0.71-0.80*	1	0	0.141-0.16*	7	0
			0.161-0.18*	1	0

*Above air quality limits

Source: T. L. Montgomery, J. M. Leavitt, T. L. Crawford, and F. E. Gartrell. "Controlling Ambient SO_2." Journal of Metals, June 1973.

Table III-4. Smelter monitor 1-hour SO_2 concentrations for three selected time periods

	Year	Greater than 0.25 ppm	Greater than 0.5 ppm
Before control	1969	102	25
After control	1972	7	1
After control	1/73-5/73	1	0

b. Effectiveness of the Measure in Current Applications. Supplementary control systems can be used effectively only under the particular restrictive conditions that are cited in part 3(b), below. The measure can be very effective in reducing ground level concentrations if properly designed and administered. In the TVA power plant example cited above, State regulations require that a maximum 3-hour SO_2 concentration of 0.5 ppm shall not be exceeded more than once per year at any point. In the year before controls were initiated, 10 excessive levels occurred within the data network (table III-3). After the controls were initiated, the 0.5 ppm standard was exceeded only two times. Furthermore, the two readings occurred at separate sampling stations.

For the copper smelter discussed above, the supplementary control system reduced the number of incidents when 1-hour ground level concentrations exceeded 0.5 ppm from 25 in 1969 to 1 in 1972 (table III-4). The primary ambient standard for SO_2 in the State of Washington prescribes that levels exceeding 0.4 ppm (1 hour) shall not be exceeded more than once per year; therefore, it is not readily apparent from table III-4 whether the supplementary control system was successful in maintaining the State air quality standards.

The effectiveness of a procedure applicable to malfunction, start-up, and shutdown operations cannot be determined readily. It is likely that such a measure in itself would not contribute significantly to the maintenance of long-term air quality standards.

3. Implementation

a. Procedure. A proposed revision to regulation 40 CFR 51 permits selective use of supplementary control systems as a temporary means of attaining and maintaining NAAQS only in cases where permanent production curtailment, shutdown, or delays in attainment of NAAQS are the only alternatives. Sources meeting the criteria set forth in part 3(b) below would probably be issued an operating permit with specific operating restrictions attached. Special provisions may have to be made to issue such permits on a case-by-case basis.

Regulation 40 CFR 60 provides that each source allow performance tests to be made on the facility. These performance tests, along with opacity tests, are the basis for determining whether good maintenance and operating procedures are being followed. Review of operating and maintenance procedures and on-site inspections are also used as checks. In addition, the source must, at the end of each calendar quarter, report emissions measured or estimated to be greater than those allowable under standards applicable during performance tests.

b. Conditions of Applicability. Criteria for use of supplementary control systems are as follows (ref. 18):

- Each candidate source must demonstrate that adequate constant emission reduction techniques are not available to attain and maintain NAAQS.
- Techniques that are available must be applied to permanently reduce emissions to the maximum extent practicable prior to application of supplementary control systems.
- A dispersion model must be used to estimate the maximum air quality concentrations that are expected after application of the control strategy, unless application is shown to be inappropriate.
- The owner or operator must be willing and able to accept full legal responsibilities for maintaining the NAAQS throughout the area in which emissions from that source significantly influence ambient air quality.
- Each source must support and participate in an appropriate research, development, engineering, and demonstration program to ensure that the supplementary control system can be replaced by constant emission limitation techniques as soon as possible.

It is estimated that fewer than 50 coal-fired electric generating plants would qualify under these criteria (ref. 18).

Because allowable emissions and associated air quality are tied to specific meteorological conditions, the regulation requires that a source must be isolated from other sources to qualify for this type of control. This requirement for enforceability precludes the use of supplementary control systems to control HC and NO_x emissions, which are emitted by mobile sources. Supplementary control systems to control CO and particulate emissions are also precluded because good constant emission reduction techniques for these pollutants are available.

Federal regulations regarding emissions during startup, shutdown, and malfunction presently pertain only to new sources. The adoption of local regulations could extend this to include existing sources.

c. Interaction With Other Measures. Stack height regulations may restrict the use of supplementary control systems since tall stacks, up to good engineering practice, may be required in order to avoid high ground level concentrations. Zoning approvals may affect whether a source can accept a long-term responsibility for maintaining NAAQS. This is a necessary condition for the use of supplementary control systems.

d. Potential Conflicts With Community Development Plans. Because supplementary control systems can be used only in a few isolated areas, there is little foreseeable conflict with other community development plans. Any negative environmental impacts are probably regarded to be less severe than the available alternatives, which include curtailment, shutdown, or delays in attainment of NAAQS.

Startup, shutdown, and malfunction procedures are not likely to conflict with community development plans or to produce negative environmental impacts.

d. Practical Limitations

1) Social acceptability. Due to the restrictive requirements for use of supplementary control systems, including isolation from other sources and acceptance by the owner/operator of complete responsibility for maintenance of air quality standards, this measure is expected to have only limited applications. Therefore, the public should not be greatly affected nor widely aware of the measure. The interim nature of supplementary control systems and their inherent flexibility both tend to negate the possibility that this measure could prevent other development within the area of influence of the source.

2) Economic feasibility. Supplementary control systems generally would be inexpensive relative to the costs of conventional control equipment (if such constant emission control techniques were available), so they may be economically attractive for eligible sources. One important economic consideration in the selection of a supplementary control system for maintenance is that it does not provide a long-term solution, and must be replaced when feasible constant control techniques are demonstrated to be available.

Special startup, shutdown, and malfunction procedures probably represent small additional costs of operating a process, and they may be required only at infrequent intervals. However, if the procedures are are not justified by lower repair costs or longer equipment life, and if they do cause an increased cost of production, it is unlikely that they will be implemented unless they are required. By requesting the sources to submit maintenance and operating procedures for approval, rather than specifying certain procedures, the sources may develop procedures that have low costs and still are effective.

Both of these measures require extensive surveillance efforts by control agencies for enforcement.

4. Evaluation of Control Measure Effectiveness

a. Ability of Measure to Maintain Standards. Supplementary control systems are desired specifically to maintain air quality standards, but it is doubtful that they could ever be employed in an AQMA because of the requirements that they can only be applied if a single source in an area is emitting the pollutant.

The procedures covering startup, shutdown, and malfunction conditions will probably not ensure that air quality standards can be maintained in a given AQMA for an extended period of time. If definitive maintenance and operating procedures are not adopted, source emissions will tend to increase as control and process equipment deteriorate with age.

b. Relative Efficiency Compared to Other Measures. Supplementary control systems can be used only in instances where constant emission controls are not feasible for attaining or maintaining SO_2 air quality standards. Furthermore, the systems are to be used only until other measures become available. Therefore, a discussion of relative efficiency is not appropriate for supplementary control systems. Enforced adherence to prescribed operating and maintenance procedures can be effective in maintaining minimum emission rates during all operating conditions.

H. STACK HEIGHT REGULATIONS

1. Definition of Measure

The use of tall stacks as a maintenance measure is intended to be applied in addition to, rather than in lieu of, stationary source emission regulations. It is recognized that, even though all sources may be operating in compliance with allowable emission rates, it may be necessary to effect a further reduction of ground-level concentrations of air pollutants as growth in the AQMA results in increased emissions. The use of a tall stack to decrease ground level pollutant concentrations is based on the following fact:

> Under any given set of meteorological conditions, the ground-level concentrations of a gaseous pollutant emitted at a constant rate into the atmosphere will become smaller as the effective height of emission of the pollutant into the air is increased (ref. 21).

Increasing the height of stacks can:

a. Reduce the frequency of occurrence of high ground-level concentrations that are experienced with shorter stacks under the following meteorological circumstances:

1) Neutral stability, high wind situations,

2) Inversion break-up situations, if the stack is sufficiently high for the plume to penetrate the simple radiation inversion caused by noctural cooling of the earth's surface, or

3) Looping situations, where the taller stack may enable slightly greater dilution.

b. Reduce the frequency of occurrence of high ground-level concentrations due to the plume being engulfed in wakes, eddies, and aerodynamic downwash associated with the facility, nearby structures, and terrain features.

Increasing the height of stacks cannot:

c. Reduce the frequency of occurence of high ground-level concentrations that are experienced with shorter stacks under the following meteorological conditions:

1) Limited mixing situations, or

2) Inversion break-up situations, when the plume does not penetrate a ground-based inversion or during an inversion aloft.

d. Reduce the peak short-term concentrations beyond 5-6 miles from the source.

e. Reduce the amount of pollution emitted.

Based on these facts, it is considered good engineering practice to construct a stack sufficiently tall to:

f. Minimize the effects of the plume being entrapped by wakes, eddies, and aerodynamic downwash at any facility whose emissions are great enough to threaten air quality standards when such conditions exist, or

g. Minimize the threat to air quality standards during neutral stability, high wind conditions.

Emission regulations that have been adopted take into account the use of stack heights based upon good engineering practice.

While tall stacks can be effective in the maintenance of acceptable air quality on a localized basis in an AQMA, tall stacks do distribute emissions over larger areas. If acceptable air quality is not being attained in these more distant areas, emissions from tall stacks can add to the existing pollutant burden.

2. Historical Review of the Measure

a. Current Application. In 1966, the Air Pollution Standards Committee of the ASME developed its first standard; APS-1, Recommended Guide for the Control of Dust Emission-Combustion for Indirect Heat Exchangers. Following the development of the second edition of APS-1 (November 1968), the committee produced ASME Standards APS-2, Recommended Guide for the Control of Emissions of Oxides of Sulfur Combustion of Indirect Heat Exchangers in January 1970. The procedures in the APS documents enable one to estimate the amount of each pollutant that may be emitted from a stack and/or the height of a stack required for any given-sized unit for specified maximum ground-level concentrations.

EPA has recognized that increasing the height of stacks plays a useful but limited role in attainment and maintenance of NAAQS. Since 1960, there has been a pronounced trend toward increasing the height of stacks. Simultaneously, there has been a trend toward substantially greater emissions at single locations. The principal application of extremely tall stacks has been for large oil- or coal-fired electrical generating boilers and major ore smelting operations.

Increasing stack heights beyond that judged to be good engineering practice is not an acceptable control measure except in very limited instances. The exceptions are presented in Vol. 38, No. 178, Federal Register, September 14, 1973, pp. 25697-25703. An extension of a stack to a height exceeding good engineering practice may be a part of a control measure to achieve air quality standards if: (1) the source is isolated, i.e., a source that accepts responsibility for all ambient

SO_2 found in its vicinity, and (2) action to increase the stack height is taken in conjunction with the development and operation of a supplementary control system.

Increasing stack heights may be an acceptable maintenance measure to decrease the effect upon ground-level pollutant concentrations of sources already in compliance with emission regulations. It must be considered, however, that tall stacks have the effect of spreading pollutant emissions over a much larger area.

b. Effectiveness of the Measure in Current Applications. The effectiveness of increased stack height in reducing ground level concentrations of sulfur oxides and particulates can be determined through the use of atmospheric dispersion models (ref. 22). It is generally agreed that the accuracy of pollutant concentrations determined by dispersion models is within a factor of about 2.

There are environmental insults, as yet unidentified, that may make it undesirable to use tall stacks. The effects of atmospheric loading of pollutants, particularly of sulfur oxides, are as yet unknown. In particular, the impact of sulfur oxides on the formation of suspended sulfates, acid rainfall, acidification of soil and water, visibility reduction, changes in the colloidal stability of clouds and changes in the transmission of radiant energy through the atmosphere have not been determined. For these reasons, in addition to the implications of the Clean Air Act, emissions reduction, rather than the use of tall stacks, is the preferred method of reducing the ground-level impact of emissions.

3. Implementation

a. Procedure. The use of tall stacks as a maintenance measure may be implemented by modification of existing emission regulations to include minimum stack height requirements. It must be emphasized again, however, that the use of tall stacks as a maintenance measure is not the same as the use of tall stacks as a condition to obtain a variance for compliance with emission regulations.

b. Conditions of Applicability. The use of minimum stack height requirements to maintain acceptable ambient air quality is applicable to all point sources provided that:

1) Sources are in compliance with existing emission regulations, and

2) Further constant emission reduction methods are not available to individual sources.

When NAAQS can only be attained by utilization of a tall stack, the height of which is constrained by good engineering practice, it is advisable that its use be accompanied by an approved supplementary control system.

c. Interaction With Other Measures. Where this measure is applied it will have an additive effect on assisting interaction with the following maintenance measures:

- Emission allocation,
- Emission density zoning,
- Emission charges,
- More restrictive source limitations and NSPS, and
- Combination of emission sources.

d. Potential Conflicts With Community Development Plans. Due to obstacle height limitations imposed by FAA requirements, the presence of tall stacks will restrict certain areas from airport development. Additionally, most State Power Plant Siting Commissions would have to approve a stack height extension.

e. Practical Limitations. In a ruling handed down February 8, 1974, the U.S. Court of Appeals for the Fifth Circuit disapproved two pertinent provisions of the Georgia implementation plan, including its variance provision and its reliance on dispersion techniques rather than emission regulations. The Court held that emission reduction techniques are clearly the preferred control methods under the Clean Air Act, and that "other measures" referred to in section 110(a)(2)(B), such as dispersion techniques, are allowed only if emission reduction techniques sufficient to meet the national ambient air quality standards are unavailable or unfeasible. The Court held that Georgia's reliance on a tall stack control technology was untenable under the act.

4. Evaluation of Control Measure Effectiveness

a. Ability to Maintain Standards. In specific cases the ability of a tall stack to maintain acceptable levels of currently established standards has been demonstrated. Requirements for minimum stack heights as a maintenance measure should be based on the demonstration of reduced spatial and temporal impact of the dispersed emissions using acceptable diffusion modeling techniques.

b. Relative Efficiency of the Measure. Use of tall stacks will reduce ground-level pollutant concentrations on a localized basis. Stacks up to the height of good engineering practice are acceptable in all cases.

Provided that a source is sufficiently isolated and that its emissions are sizeable (greater than 1,000 tons per year), increasing the height beyond good engineering practice to dilute emissions can be as efficient as engineering limitations on height will permit. As previously noted, the acquired ground-level control effectiveness of the stack must be guaranteed by a concurrent supplementary control system. This supplementary control system is a procedure to limit the rate of pollutant emission when meteorological conditions conducive to ground-level concentrations in excess of national standards exist or are anticipated.

Construction of tall stacks does not require materials or skills in short supply and can usually be accomplished in months rather than years. Obviously, its total effectiveness is limited by the number of source applications in any AQMA. However, if and when ambient standards are set for materials such as sulfates or fine particulates, tall stacks will only serve to compound the environmental insult.

I. CONTROL OF FUGITIVE DUST SOURCES

1. Definition of Measure

Construction activity is the most significant fugitive dust source in most AQMA's. The primary construction sources are highway, residential, commercial, and industrial construction projects. In addition, fugitive dust emissions from unpaved roads and agricultural activities indigenous to the arid and semiarid areas of the Great Plains, Far West, and Southwest, can have a considerable effect on the air quality of AQMA's in these regions. Other fugitive dust sources, such as material storage piles and unpaved parking lots, may have a localized impact on air quality but rarely are widespread enough to affect AQMA air quality. Total suspended particulates is the only pollutant resulting from fugitive dust sources.

Several methods have been employed to reduce the dust emissions from construction sites, including those listed below (ref. 23). Expected average control efficiencies are shown in parentheses.

- Watering (50%)
- Chemical stabilization of completed cuts and fills (80%)
- Treatment of temporary access and haul roads on or adjacent to site (50%)
- Minimal exposure periods for active construction areas (50%).

While these measures have relatively low control efficiencies compared to other particulate controls, they are proven techniques that can be enforced as regulatory requirements. Rigorous control of construction activities and other fugitive dust sources provide emission reductions from a source category that is presently controlled through nuisance provisions. Hence, it can be considered as a maintenance measure.

Control measures to reduce the particulate emissions from agricultural sources consist of the same measures presently employed for conservation of topsoil from erosion. These measures consist of:

- Continuous cropping (25%)
- Limited irrigation of fallow fields (20%)
- Windbreaks (5%)
- Interrow plantings of grain on widely spaced row crops (15%)
- Stubble, crop residue, or mulch left on fields after harvest for wind protection (10%)
- Spray-on chemical stabilization (40%)

Fugitive dust emissions from unpaved roads have been controlled by:

- Paving and right-of-way improvement (85%)
- Surface treatment with penetration chemicals (50%)
- Soil stabilization chemicals worked into the roadbed (50%)
- Speed control (10 to 40%).

2. Historical Review of Control Measure

a. Current Applications. Several local and State control agencies, including Pima and Maricopa Counties in Arizona, have passed regulations requiring permits to construct on a property. The permit applications must state the dust control method to be used, and it is subject to revocation for failure to implement the control.

The State of Colorado requires that a control plan be submitted by any construction source if a visible plume is observed at the property line or if a plume of greater than 20 percent opacity is observed at any point on the site for more than one minute duration. The control plan must contain one of the "recognized control methods" endorsed by the agency.

The State of Nevada has specifications written into State construction contracts requiring stabilization of all completed cuts and fills. Most states have had regulations for dust control on highway projects as an integral part of their highway construction standards for some time. EPA has conferred extensively with the U.S. Department of Agriculture in attempting to develop enforceable means of reducing the contribution of agricultural dust emissions in arid areas. However, the only recommendation to date is a program of education in soil conservation and dust control methods. The State of Colorado's Air Pollution Control Division has excluded agricultural sources from its fugitive dust control regulations.

b. Effectiveness in Current Applications. Isolation of the impact of stringent dust control regulations on both regional and localized particulate concentrations is difficult because of the many fugitive dust sources in most of the areas where these controls have been implemented.

Based on emissions data, construction may account for up to 10 percent of particulate emissions in metropolitan areas (ref. 23); consequently, a comprehensive control regulation could reduce emissions by as much as 5 percent.

3. Implementation

a. Procedure. Most of the measures to reduce air pollution in highway construction or building construction could be controlled by additional provisions to construction specifications and building codes or by air pollution control regulation. Several agencies have passed regulations requiring permits to construct on a site. In order to obtain and keep a permit, the contractor must have an approved plan to control dust. This is an enforcement aid, since the permit can be revoked if a dust problem is observed on the site.

Use of the permit system could be extended to provide another control technique--minimal exposure of barren areas. Part of an approved plan for large sites would provide for grading and other earth-moving work on portions of the site followed by treatment of the finished portion prior to opening a new section to clearing and regrading. Long-duration development of large tracts could also be effectively regulated to prevent windblown dust problems. Any permit program requiring minimal exposure periods should require submittal of detailed plans and schedules. Subsequent field inspections by enforcement personnel would be essential to ensure adherence to the plans.

Implementation of control measures for unpaved roads would require coordination with highway departments and provision of funds to pave or otherwise upgrade unpaved road surfaces. One effective measure in rapid growth areas is to prohibit the construction of new unpaved roads.

b. Conditions of Applicability. Fugitive dust control measures are applicable whenever the particulate emissions from these sources contribute significantly to the total particulate concentration of an AQMA.

c. Interaction With Other Measures. The temporary and intermittent nature of most fugitive dust sources would cause these sources to interfere with some of the approaches to air quality maintenance such as emission allocation or emission density zoning. Therefore, control of this often-ignored source category could make these approaches more workable.

d. Potential Conflicts and Negative Impacts. Implementation and enforcement of fugitive dust control measures necessarily involve the interaction of air pollution control agencies with such groups as highway departments, building departments, highway patrols (for speed control on unpaved roads), and the Department of Agriculture. For this reason, whenever the activities and goals of these cooperating organizations are divergent from those of the air pollution control agency, a potential conflict is created. For example, rigorous dust control measures on a highway construction project might cause construction delays and subsequent failure to meet deadlines.

e. Practical Limitations.

1) Social acceptability. Social acceptability to con-

struction activity control measures would be favorable, since the resulting decrease in airborne dust from these projects would be tangible evidence of improved conditions to the surrounding populace.

Acceptance of the unpaved road dust control measures would be mixed. Reaction to a decrease in road dust would be good; however, the inconvenience to the motorist of the control measures, e.g., speed control and detours, would certainly cause a negative reaction. Keeping the public educated on the advantages of such control measures greatly enhances their acceptability.

2) Economic feasability. Cost data for most fugitive dust controls are presented in ref. 23. In general, the cost of dust control programs on construction sites is a very small portion of total construction costs and can be included in those costs. However, because of the extent of unpaved roads and agricultural activities, the total costs to control emissions from these categories may make these infeasible.

4. Evaluation of Control Measure Effectiveness

The effectiveness of the measure is dependent on the percent contribution from fugitive dust emissions in the AQMA projected emission inventory. Specific construction sources and their locations change with time. Since new development is occurring in the AQMA (by definition), emissions from these sources should continue, even though they are continually changing in location. The problem of construction activities in a "hot spot" causing the standards to be exceeded would be minimized by other measures of the maintenance strategy that would discourage further permanent development in that area. If it is denoted as a problem area, special dust control requirements might be placed on construction activities.

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Chapter IV: INTERRELATIONSHIPS AMONG MEASURES

Many of the measures proposed for maintaining air quality standards are not completely independent of one another, but have either beneficial or detrimental effects if they are implemented concurrently. It is important that these interactions be recognized when maintenance strategies are being formulated so that, if combinations of measures are necessary, those that are compatible can be supported and those that are not can be avoided.

The most significant interrelationships for each measure were described in some detail in chapters II and III. The purpose of this chapter is to present a more systematic procedure for assessing interactions. This procedure (ref. 1) utilizes a matrix of all the measures under consideration, as shown in table IV-1. Four symbols are used to qualitatively describe the different relationships that may exist between two measures:

A--The measures assist each other either by facilitating implementation or by increasing their combined effectiveness.

C--The measures are complementary; they act on different sources or in a different manner to mutually produce combined improvements. One measure may be a component or instrument of the other.

I--The measures are independent of each other; neither will enhance nor deter the effectiveness of the other.

O--The measures have some overlapping in their emission reduction or location objectives, are competitive, may preempt each other, or be otherwise incompatible.

Theoretically, two measures could also be counterproductive to each other. However, none of the maintenance measures were observed to have this relationship, so it has been omitted.

The interrelationship between emission allocation and emission density zoning is an example of how one measure can assist in the

Table IV-1. Interrelationships among maintenance measures

	Emission allocation	Regional development planning	Emission density zoning	Zoning approvals & other indirect regulatory controls	Transportation controls	Emission charges	Transfer of emission source locations	Indirect source review	Environmental impact statements	New source performance standards	More restrictive source emissions limitations	Phase-out or prohibition of specified source categories	Fuel conversion	Energy conservation and utilization	Combination of emission sources	Special operating conditions	Stack height regulations	Control of fugitive dust sources
LAND-USE AND PLANNING MEASURES																		
Emission allocation		C,O	A	O	C,I	O	A	C,I	I	C	C,O	C	A	C	C	O	C	C
Regional development planning	C,O		C,O	A	C,O	O	C	C	A	C	C	C	C	C	A	I	I	I
Emission density zoning	A	C,O		O	I	O	A	I	I	C	C	C	A	C	C	O	C	C
Zoning approvals & other indirect regulatory controls	O	A	O		I	O	C	I	I	I	I	I	I	I	I	I	I	I
Transportation controls	C,I	C,O	I	I		C	I	A	C	I	I	I	I	I	I	I	I	I
Emission charges	O	O	O	O	C		O	I	I	I	O	I	I	I	I	I	C	I
Transfer of emission source locations	A	C	A	C	I	O		I	I	I	C	C	I	I	C	I	I	I
Indirect source review	C,I	C	I	I	A	I	I		A	I	I	I	I	I	I	I	I	I
Environmental impact statements	I	A	I	I	C	I	I	A		I	I	I	I	I	I	I	I	A
EMISSION CONTROL MEASURES																		
New source performance standards	C	C	A,O,C	I	I	I	I	I	I		I	I	I	I	C	I	C	I
More restrictive source emission limitations	C,O	C	C	I	I	O	C	I	I	I		C	I	I	I	I	C	I
Phase-out or prohibition of specified source categories	C	C	C	I	I	I	C	I	I	I	C		I	I	C	I	I	I
Fuel conversion	A	C	A	I	I	I	I	I	I	I	I	I		C	I	I	I	I
Energy conservation and utilization	C	C	C	I	I	I	I	I	I	I	I	I	C		A	I	I	I
Combination of emission sources	C	A	C	I	I	I	C	I	I	C	I	C	I	A		I	C	I
Special operating conditions	O	I	O	I	I	I	I	I	I	I	I	I	I	I	I		C	I
Stack height regulations	C	I	C	I	I	C	I	I	I	C	C	I	I	I	C	C		I
Control of fugitive dust sources	C	I	C	I	I	I	I	I	A	I	I	I	I	I	I	I	I	

LEGEND:
A - MEASURES THAT ASSIST EACH OTHER IN MAINTAINING AIR QUALITY.
C - MEASURES THAT ARE COMPLEMENTARY IN MAINTAINING AIR QUALITY.
I - MEASURES THAT ARE INDEPENDENT OF EACH OTHER IN MAINTAINING AIR QUALITY.
O - MEASURES THAT MAY OVERLAP OR PREEMPT EACH OTHER IN MAINTAINING AIR QUALITY.

the implementation of another. Emission allocation prescribes the total allowable emissions in an area. Emission density zoning provides a means of implementation by distributing the allowable emissions throughout the area on the basis of land use. More restrictive source emission regulations and stack height regulations are examples of complementary measures. Implementation of the first results in a reduction of emissions, the second in a spatial distribution of the reduced emissions. An example of measures that are independent of each other is found in the combination of Environmental Impact Statements (EIS's) and New Source Performance Standards (NSPS). The EIS's are applicable during the planning and preplanning stages, NSPS to the construction and implementation. Zoning approval and emission changes are examples of measures that may overlap or preempt each other. Zoning restrictions could prohibit the construction or modification of a source that, if built, would produce emissions subject to emission charges.

This approach to evaluation of interactions involves some subjective categorizations, but it provides a simple method of organizing the evaluation results for grouping of the measures. Some of the measures are so broad in scope and may interact in such complex manners that a single descriptive categorization may not be adequate. For example, a regional land-use plan could encourage high-density corridor developments in an urban area to increase mass transit usage and reduce VMT. In one AQMA, this may be interpreted as assisting transportation controls in maintaining standards, while in another it may be considered overlapping. The analysis of interrelationships should be made specifically for each AQMA based on local conditions. The results may be different from those shown in table IV-1. In general, the same interactions will exist regardless of whether the two measures are being used for control of the same pollutant or for two different pollutants.

Although the following conclusion is not evident from the results of the matrix analysis, most of the land-use and planning measures (except the review procedures) represent comprehensive approaches to air quality maintenance and, as such, are mutually exclusive alternatives. The generalization can also be made that most of the emission control measures can usually be implemented within the framework of different land-use and planning measures, and may be the specific actions taken to effect emission reductions that are needed under a land-use and planning measure.

In cases where implementation of a single maintenance measure involves several actions, e.g., transportation controls, an analogous matrix for intrameasure relationships should be developed, so that these are adequately considered in designating the actual actions to be implemented. The intrameasure interactions are highly dependent on local conditions, both in determining which individual controls are applicable and what the impacts are among them.

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